Appendix

Benchmark Values and Airline Schedules

Introduction

Airport delay can be expected when too many aircraft want to use the same runway or airspace at the same time. At the major airports, scheduled traffic by air carriers and commuters is the main component of total operations, and thus is an important factor in airport delays. On the following pages, air carrier schedule data from the Official Airline Guide (OAG) is compared to the capacity benchmarks at ten of the busiest and most delayed airports in the country.

Airline Schedule-Benchmark Charts

Charts comparing schedule and benchmark data were generated for ten major airports:

- Chicago O'Hare International Airport (ORD)
- Dallas/Fort Worth International Airport (DFW)
- Fort Lauderdale-Hollywood International Airport (FLL)
- Hartsfield-Jackson Atlanta International Airport (ATL)
- Houston George Bush Intercontinental Airport (IAH)
- Minneapolis-St. Paul International Airport (MSP)
- New York LaGuardia Airport (LGA)
- Newark Liberty International Airport (EWR)
- Philadelphia International Airport (PHL)
- Washington Dulles International Airport (IAD)

Each chart depicts scheduled traffic (arrivals, departures, or total operations) by 15-minute periods from 7 AM until 10 PM local time. The schedules for each day of the week, Sunday through Saturday, were averaged over three months for both a peak and an off-peak season at each airport. Although traffic on weekdays is slightly higher than traffic on the weekends, using the schedule for all seven days allowed us to include the busy Sunday evening period.

Each chart also shows the Current Optimum and IFR benchmark values, adjusted for the 15-minute period, as well as the *average called rates* during the given period, by 15-minute period.

The arrival and departure benchmark rates indicate the number of flights that the airport could be expected to handle during an hour, given a typical operational configuration. The actual number of operations (or *throughput*) during that period is a result of many factors such as traffic schedules, weather, and the runway configuration in use. En route airspace congestion and delays at other airports may also affect throughput, especially if flow management measures such as ground delay programs are implemented. The ATC facility at the airport constantly advises the Air Traffic Control System Command Center (ATCSCC) on the number of arrivals and departures that they expect to be able to handle based on conditions at the airport, taking into account the weather and runway configuration. These airport *called rates*, the Airport Arrival Rate (AAR) and the Airport Departure Rate (ADR), reflect actual conditions at the airport during the given time period. The called rate may be as high as the Optimum rate or lower than the IFR rate; the average usually lies in between, depending on the weather and runway configurations in use during the charted period.

A sample chart, for arrivals at EWR during the period of May-July 2004, is presented in Figure A-1.

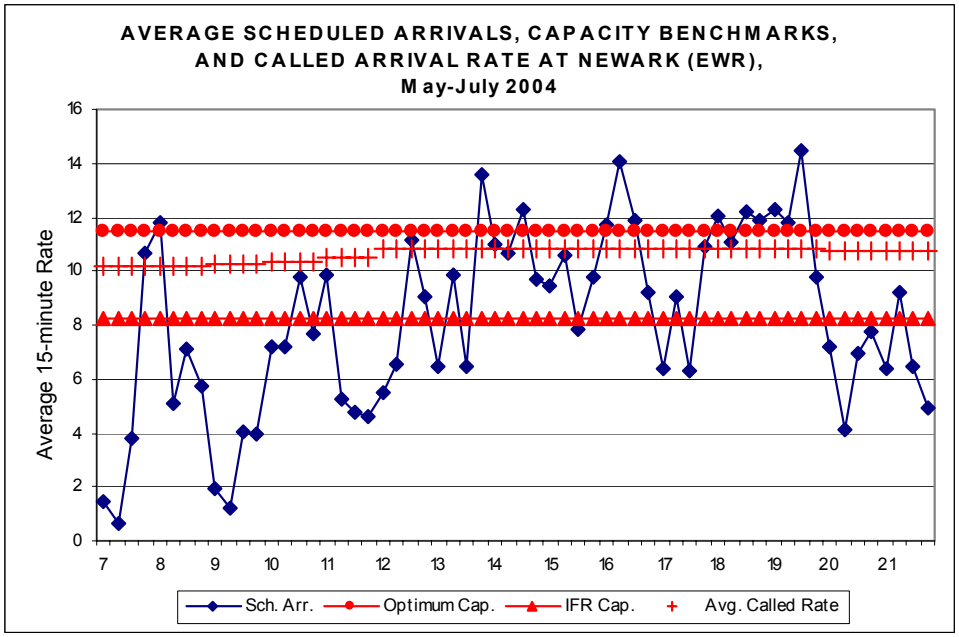


Figure A-1 – Schedule vs. Benchmarks at EWR

Scheduled and Non-scheduled Traffic

Scheduled carrier operations constitute a significant part, but not all, of an airport's traffic. Non-scheduled traffic includes air taxi flights, military operations, general aviation (including charter flights), and some cargo operations. Scheduled flights, including air carriers and commuter carriers, accounted for approximately 78-98 percent of the total traffic at these ten airports during 2002 and 2003, according to the FAA Terminal Area Forecast[1] (see Table A-1).

Table A-1
Selected Airports and Percentage of Scheduled Operations

Airport	Airport Name	Air Carrier, Commuter and Air Taxi Operations
ATL	Hartsfield-Jackson Atlanta International Airport	98%
DFW	Dallas/Fort Worth International Airport	97%
EWR	Newark Liberty International Airport	97%
FLL	Fort Lauderdale-Hollywood International Airport	78%
IAD	Washington Dulles International Airport	79%
IAH	Houston George Bush Intercontinental Airport	95%
LGA	New York LaGuardia Airport	97%
MSP	Minneapolis-St. Paul International Airport	89%
ORD	Chicago O'Hare International Airport	97%
PHL	Philadelphia International Airport	86%

[1] The Terminal Area Forecast provides data on Commuter (scheduled) and Air Taxi (unscheduled) operations combined. The percentages shown in Table A-1 include some unscheduled Air Taxi operations, and therefore overstate the actual percentage of scheduled operations. However, the number of Air Taxi operations is generally small (estimated to be 2-5 percent of total traffic).

The following charts depict only airline and commuter schedules. The effect of the non-scheduled traffic is uncertain. Some of the non-scheduled flights may use a separate runway, as at FLL, or they may try to avoid operating during the busy periods for the air carriers. However, non-scheduled flights might contribute to delay during the busy times of the day at some airports, even though air carrier operations are the main component of operations at these ten airports

Arrival and Departure Benchmarks

The overall benchmark rate for total arrivals and departures at an airport generally assumes a balanced operation, with equal numbers of arrivals and departures. In the long run, the number of aircraft that land at an airport will equal the number of aircraft that take off. But from hour to hour, the number of scheduled arrivals may be much more or much less than the number of scheduled departures.

Some airports will change their operations to handle such unbalanced demand, and this affects their arrival and departure benchmark rates. For example, IAD can handle 90 arrivals per hour ***or*** 75 departures per hour – but not both in the same hour. The benchmark for IAD is 135 operations per hour in Optimum weather conditions. It is possible to schedule fewer than 135 total operations in a single hour, yet still exceed the departure benchmark rate of 75. Conversely, it is possible to schedule more than 135 operations per hour without exceeding either the arrival or the departure benchmark rate.

To recognize such cases, three charts were prepared for each airport:

- Scheduled arrivals versus the arrival benchmark rate
- Scheduled departures versus the departure benchmark rate
- Scheduled total traffic, arrivals and departures, versus the benchmark rate for total traffic.

This allows us to identify whether the scheduled traffic exceeds the arrival capacity of the airport, its departure capacity, or its combined capacity.

Schedule, Capacity, and Delay

In the following charts, the airline schedule lines exhibit several peaks where the number of scheduled operations exceeds the Optimum benchmark value, and even more instances where the schedule exceeds the IFR benchmark. If the scheduled operations are greater than the benchmark value for a given time period, some of those scheduled operations may be delayed until the next time period. Airline “overscheduling” – scheduling more flights than the airport can be expected to handle during that time period – is thus one factor in airport delay.

A small amount of overscheduling is not necessarily undesirable, and may actually enhance the efficiency of the airport. Flights do not always operate on schedule: they may arrive early due to favorable winds, or they may leave the gate late due to mechanical problems. Some overscheduling during busy periods helps to ensure that there is always an aircraft waiting to use the runway despite such schedule deviations. An airport runway is a limited resource; if it goes unused because no aircraft is available to use it, the opportunity is lost and cannot be reclaimed.

The airlines may also have business reasons for overscheduling. Each airline would like to maximize their market share, and to do so they will schedule flights during the preferred morning and evening travel times. An airline with a hub operation at the airport may schedule a bank of arrivals, followed by a bank of departures. The airline may overschedule these banks knowing that some flights will arrive early and some will be late, with the net effect of having continuous demand at the runway end.

The amount of delay caused by overscheduling depends on many factors, but one of the main factors is the availability of compensating “underscheduled” periods during the day. If a schedule peak is followed by an equivalent or greater “valley”, then the scheduled traffic can be handled in the next time period and delays will be short. If the peak extends over several time periods,

however, it will take longer to eliminate the backlog of waiting flights, and delays will increase accordingly.

Other Factors Affecting Actual Operations and Delay

Delay occurs when there is more demand than the airport can accommodate. Persistent, severe levels of delay are primarily due to excess levels of traffic, which at these airports is mainly scheduled airline traffic.

The following charts of scheduled airline traffic versus the benchmarks are intended to illustrate the general situation at each airport. The actual delay at each airport, however, is governed by many factors, some of which do not appear on these charts. These factors include:

Actual Flight Times: Airline schedules are generally based on block times between airports, and may include an additional time margin to compensate for congestion or other factors. Actual arrival times may therefore be earlier or later than the scheduled time on a given day due to non-airport factors. The scheduled arrival and departure times may not therefore represent the actual pattern of operations at the airport.

Schedule Distribution: The delay experienced by flights in a given time period is also affected by the distribution of flights within that time period. Clustering of flights within the time period will lead to more delay than if the flights were evenly distributed. For example, suppose that a runway can accommodate one departure each minute. If the schedule provides one departure per minute, delays will be minimal. However, if 15 departures leave the gate at the same time, one will be delayed by a minute, another by two minutes, and so forth, with the last departure delayed by 14 minutes.

Arrival/Departure Priority: At many airports, more arrivals can be handled if fewer departures are scheduled for that time period, and vice versa. Such airports (like IAD) may use different runway configurations for an arrival peak versus a departure peak, or arrival separation may be increased to allow one or more departures between each arrival pair. The benchmark rate, however, reflects just a single mode of operation, usually balanced operations. The benchmark rate may therefore underestimate the ability of the airport to accommodate schedule peaks.

Weather: One weather effect is apparent in the following charts: the IFR benchmark is lower than the Optimum benchmark. As ceiling and visibility decrease, the number of operations per hour that the airport can handle also decreases. Wind speed and direction can also affect airport capacity by forcing the use of less efficient runway configurations. Even with the highest ceilings and visibilities, an airport may not be able to achieve the Optimum benchmark rate if it is forced to operate in a different runway configuration.

Environmental Constraints: The runway configuration in use may also be affected by local environmental restrictions, such as a requirement to “rotate” runway usage over the day. Such restrictions usually require the use of runway configurations that are less efficient but which reduce noise exposure in sensitive areas.

Non-Runway Factors at the Airport: Delays can also be caused by factors besides the runway. Congestion in the ramp area or on taxiways can keep aircraft from getting to the runway or to the gate in a timely manner. An arrival might find its gate still occupied by an earlier flight, and be delayed waiting for that gate or another to become free. The aircraft at the gate might be delayed on departure if it was late arriving, since a minimum amount of time is still required to unload arriving passengers and baggage, clean the aircraft, and load departing passengers and baggage.

Non-Airport Factors: Lastly, events away from the individual airport can lead to flight delays. En route weather is one example, particularly thunderstorms that close one or more airways. Flights may be held in the air or on the ground as needed to avoid exceeding the capacity of the remaining available airways. Aircraft may also be held on the ground because of congestion at the destination airport, to avoid airborne holding en route or in the terminal area.

Examples of Schedules and Delays

Certainly the airline schedule is one factor affecting delay, but actual delays are the product of many different factors, particularly weather. The same schedule can be in effect on two different days with very different delay results. For example, the airline schedules at ORD on 12 July and 16 July 2004 were essentially identical. However, according to OPSNET data, 23 percent of all operations on 16 July were delayed more than 15 minutes, while only 3 percent were delayed on 12 July.

Figures A-2 and A-3 depict operations on these days, from 7 AM to midnight local time. In each figure, the schedule of operations is shown by a solid line, while actual operations appear as vertical bars. The called arrival rate, the AAR, is also shown as a line.

Clearly, operations on 16 July were affected by a reduction in the AAR between 1:30 PM and 6:30 PM, first to 80 per hour and then to 40 per hour (10 per 15 minute period). This may have been due to thunderstorm activity. A reduction in departures is also apparent.

The largest difference in the schedule for the two days was only three arrivals, and only two departures, over any 15 minute period. However, there were as many as 17 fewer arrivals in a 15-minute period on 16 July (during four different 15-minute periods between 4 PM and 7 PM), and as many as 19 more at 10 PM. Apparently flights were restricted in the afternoon and the backlog lasted until late in the evening. Similarly, there were fewer departures early in the day and more departures after 10 PM.

Airline scheduling practices can lead to delays on the best weather days, as overscheduling can eliminate the ability of the airport to recover from other operational problems. Overscheduling will exacerbate the effect of bad weather, leading to long delays and cancellations. However, it should be kept in mind that the schedule is only one factor affecting delays.

Schedule-Benchmark Charts for Ten Airports

Charts showing airline schedules and capacity benchmarks at ten of the busiest and most delayed airports in the country were prepared for two time periods: January-March 2004 and May-July 2004. Separate charts were prepared for arrivals, departures, and total traffic (arrivals plus departures). These charts appear on the following pages.

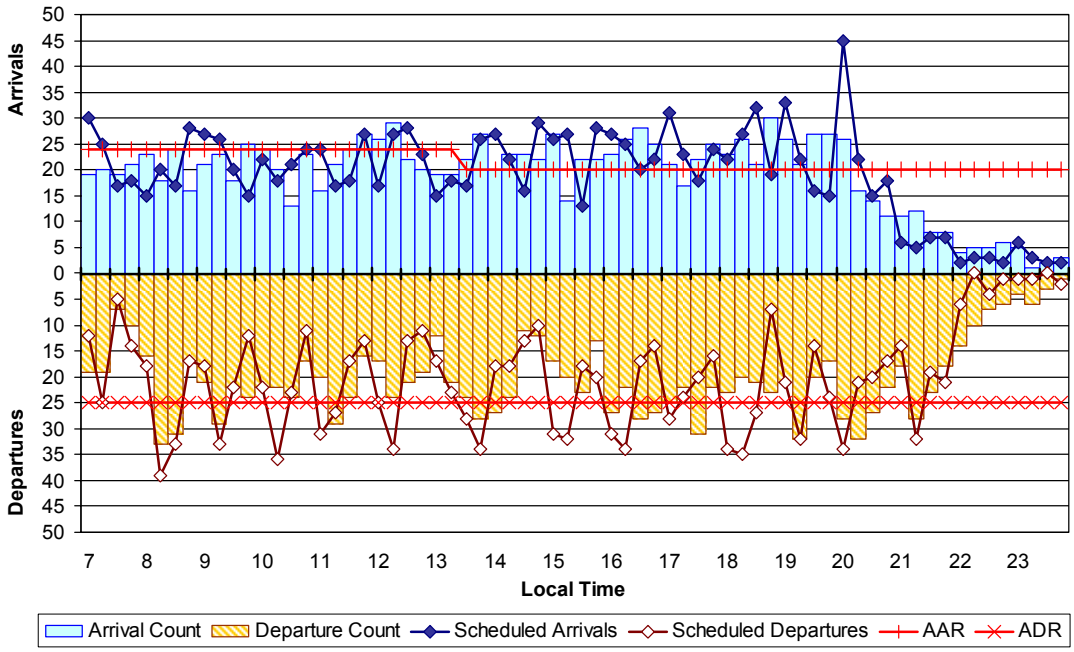


Figure A-2 – 12 July 2004 (Monday) at ORD

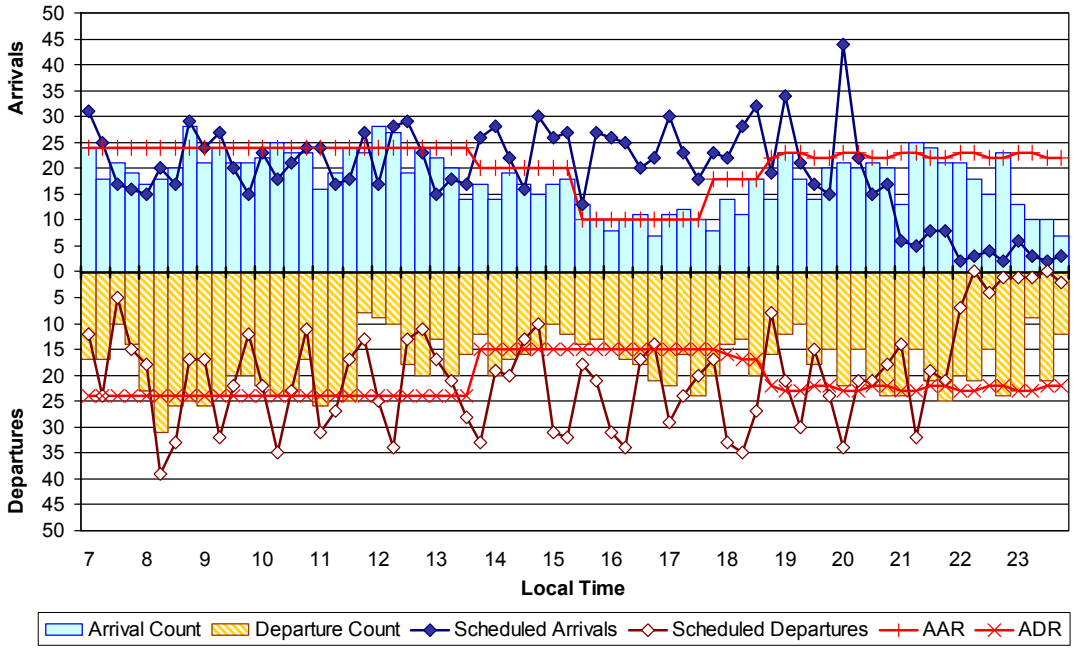
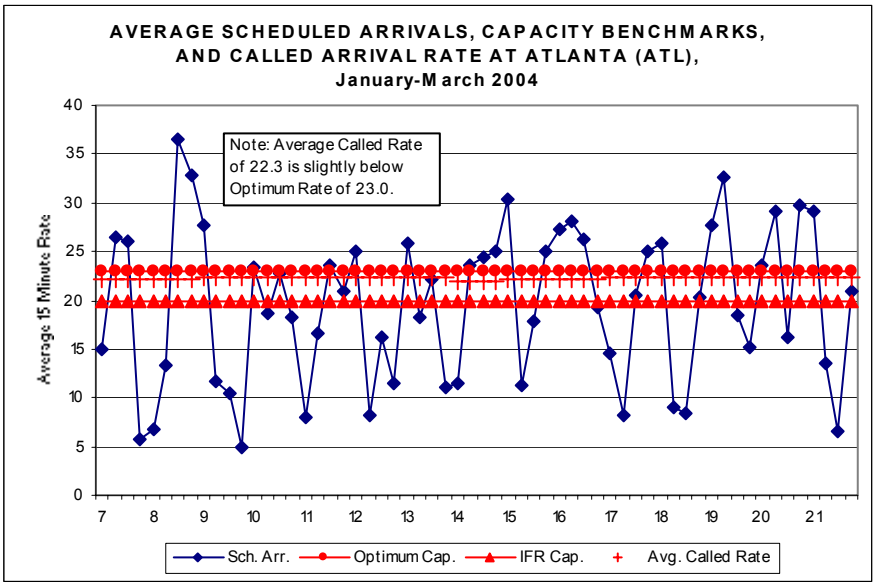


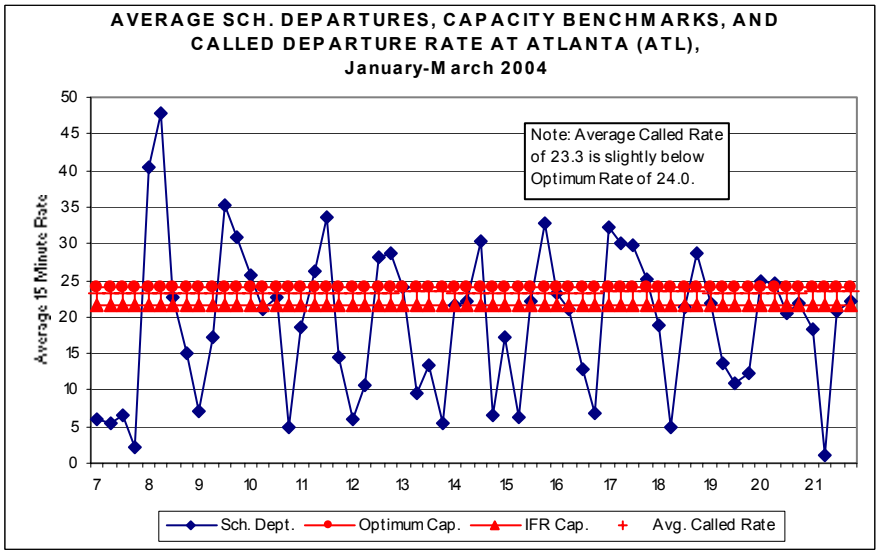
Figure A-3 – 16 July 2004 (Friday) at ORD

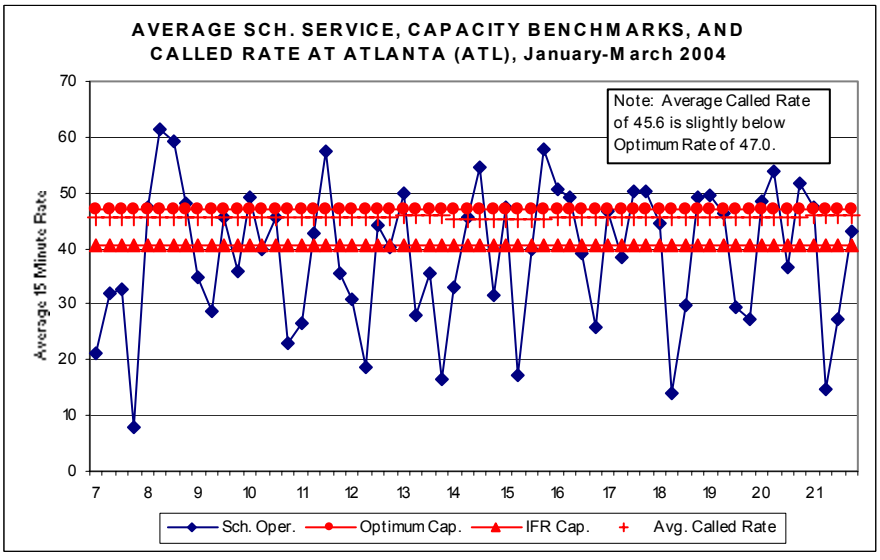
Table of Schedule-Benchmark Charts

Airport	Airport Name	Page
ATL	Hartsfield-Jackson Atlanta International	A-8
DFW	Dallas/Fort Worth International	A-10
EWR	Newark Liberty International	A-12
FLL	Fort Lauderdale-Hollywood International	A-14
IAD	Washington Dulles International	A-16
IAH	Houston George Bush Intercontinental	A-18
LGA	New York LaGuardia	A-20
MSP	Minneapolis-St Paul International	A-22
ORD	Chicago O'Hare International	A-24
PHL	Philadelphia International	A-26

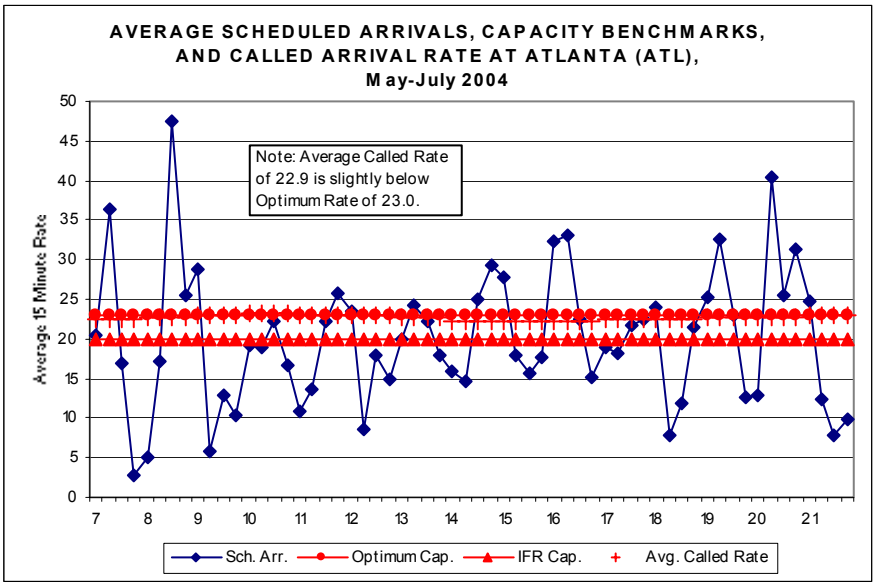
ATL – Hartsfield-Jackson Atlanta International
January-March 2004

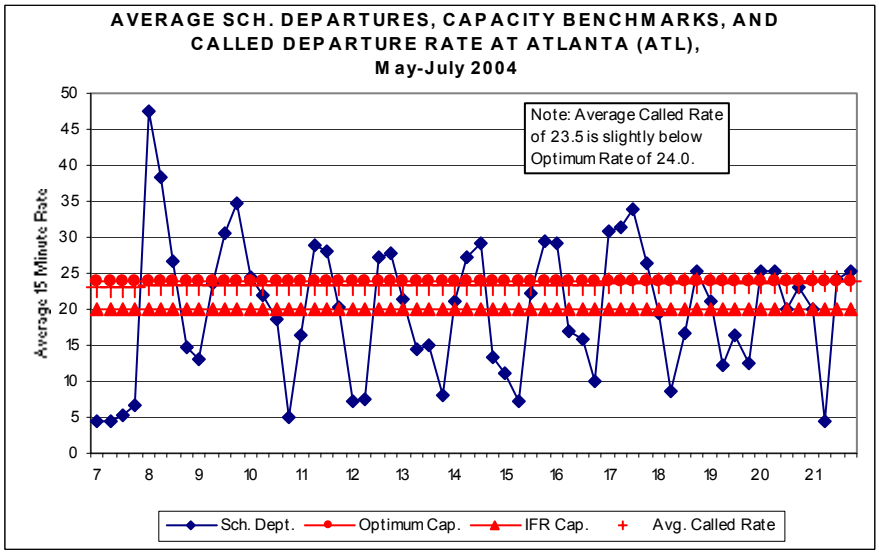


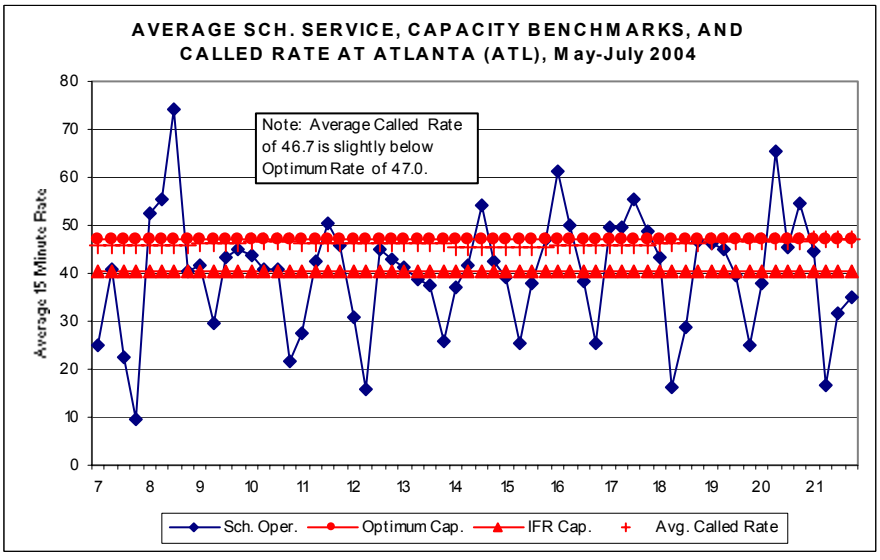




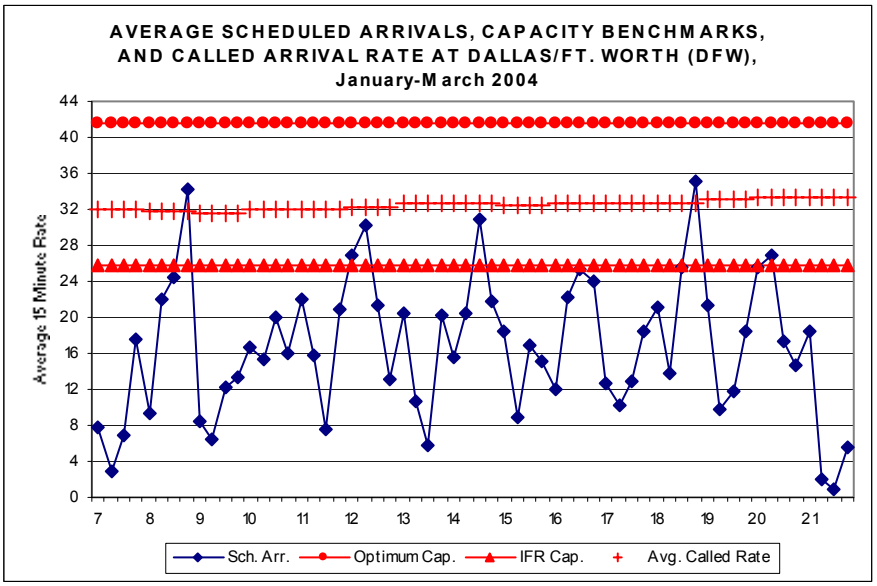
ATL – Hartsfield-Jackson Atlanta International
May-July 2004

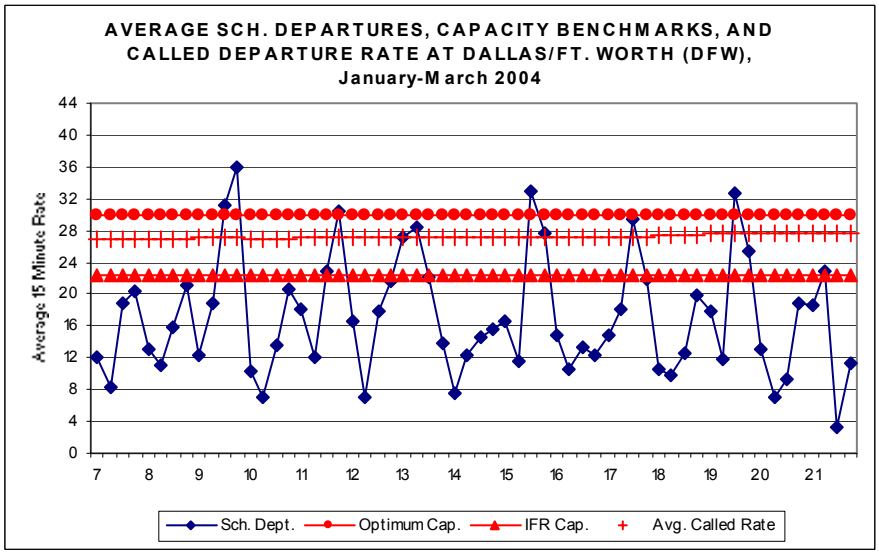


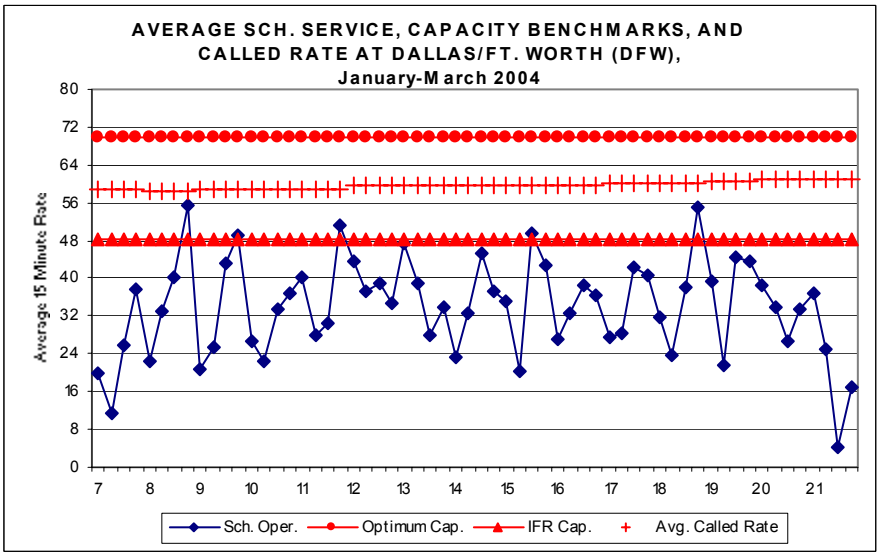




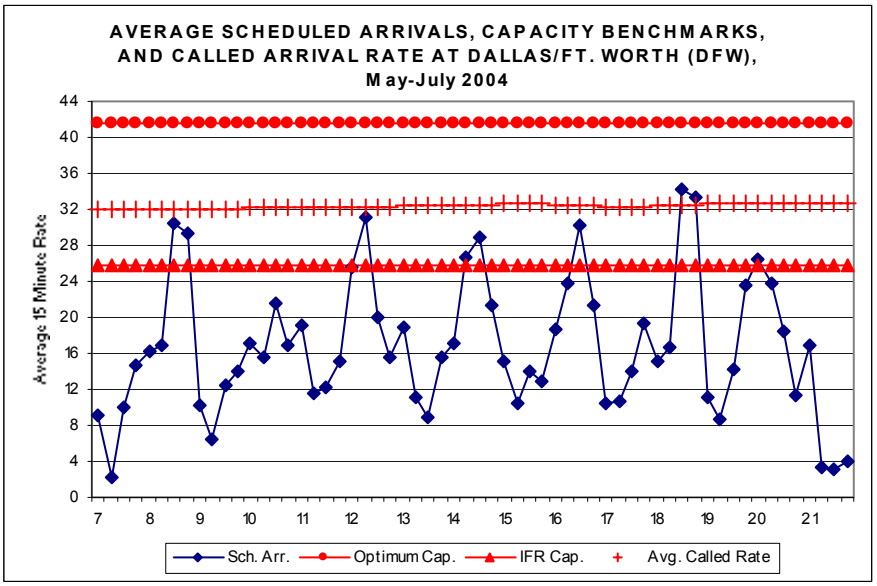
DFW – Dallas/Fort Worth International
January-March 2004

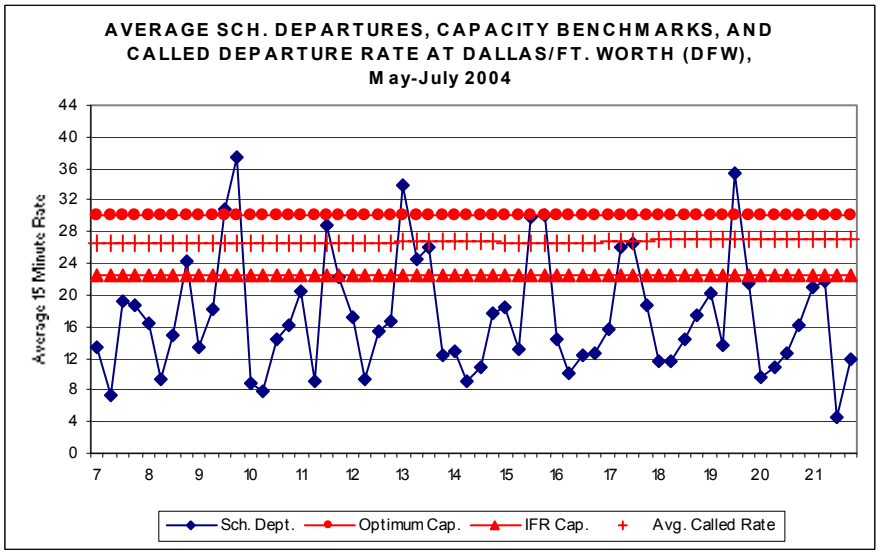


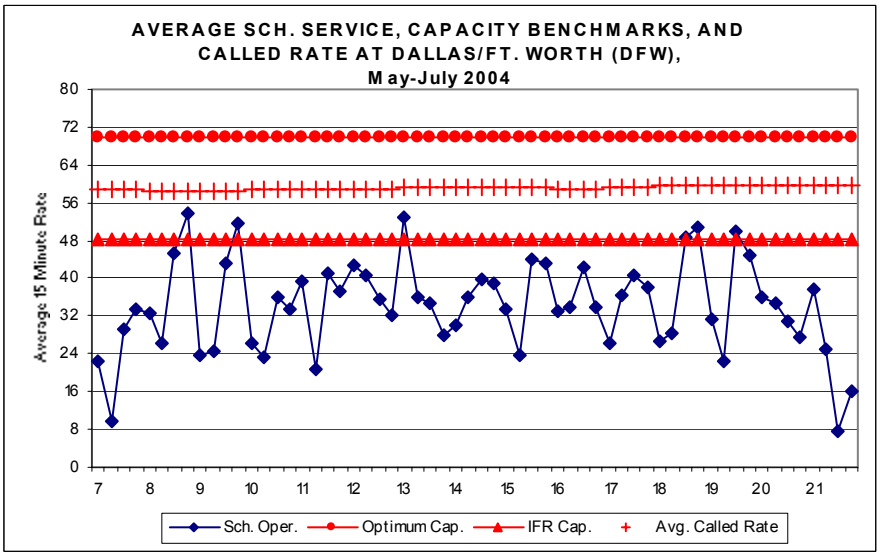




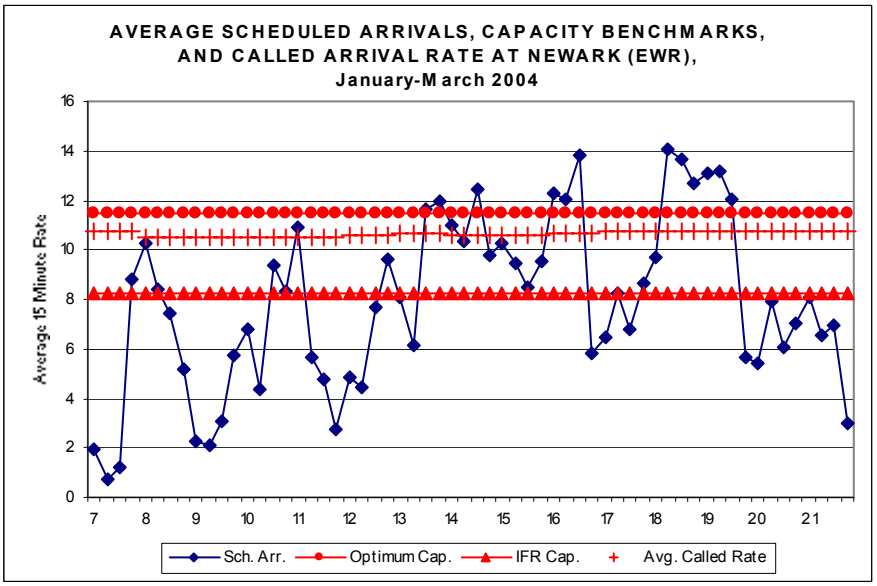
DFW – Dallas/Fort Worth International
May-July 2004

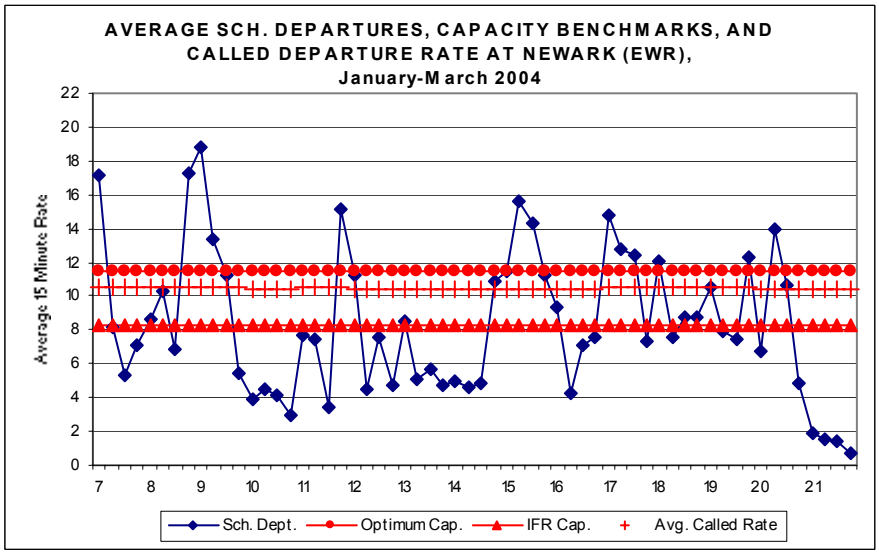


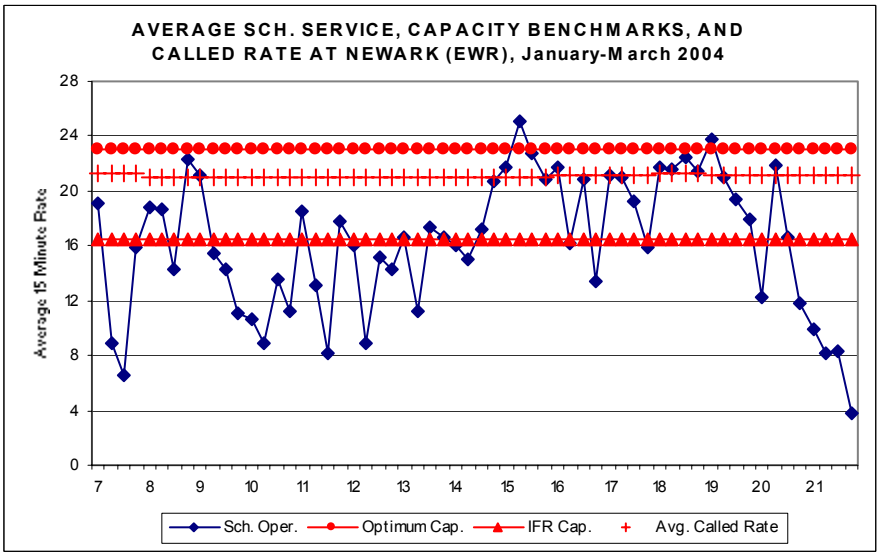




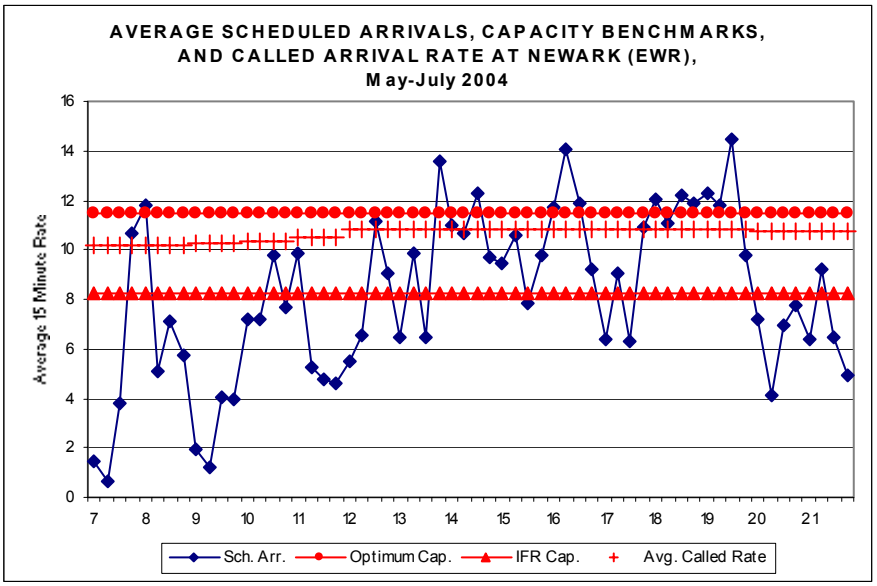
EWR – Newark Liberty International
January-March 2004

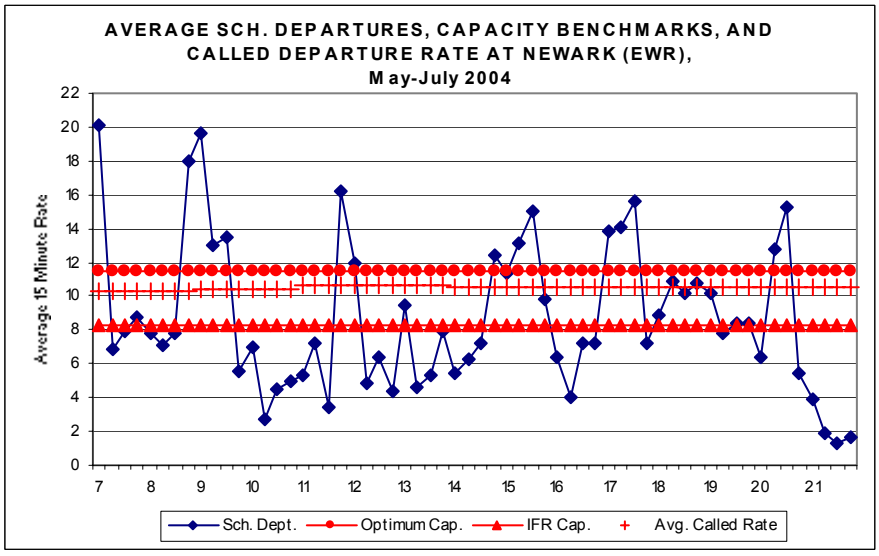


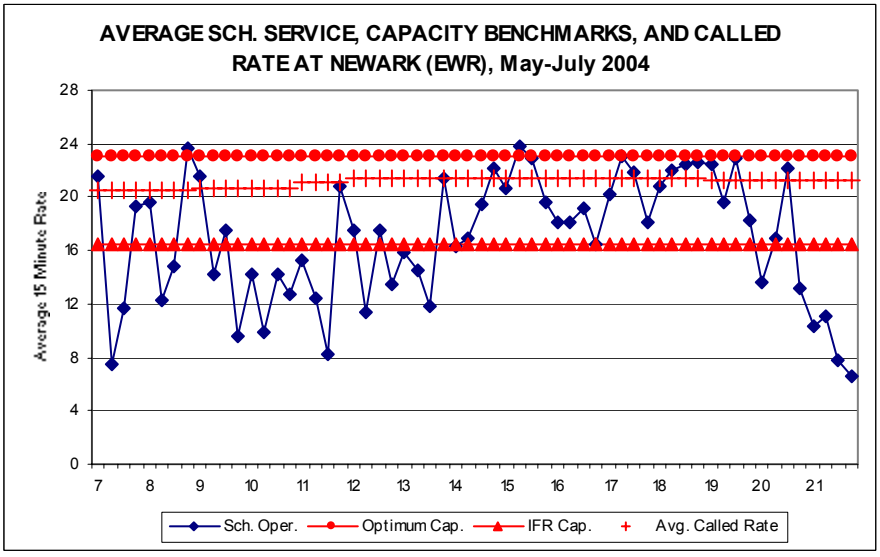




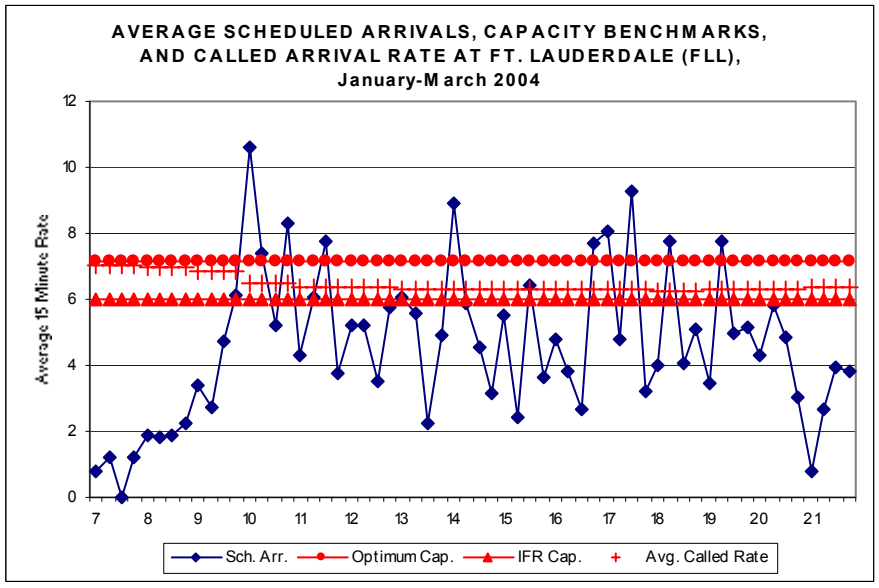
EWR – Newark Liberty International
May-July 2004

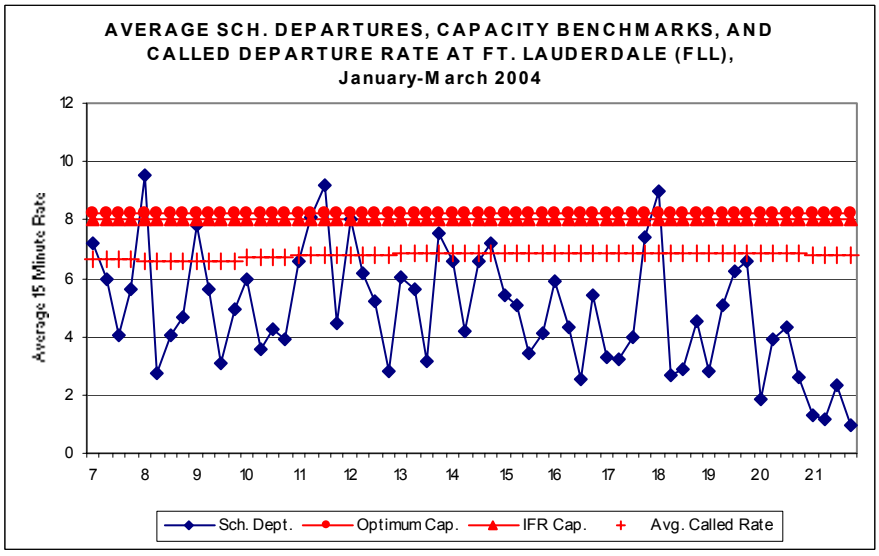


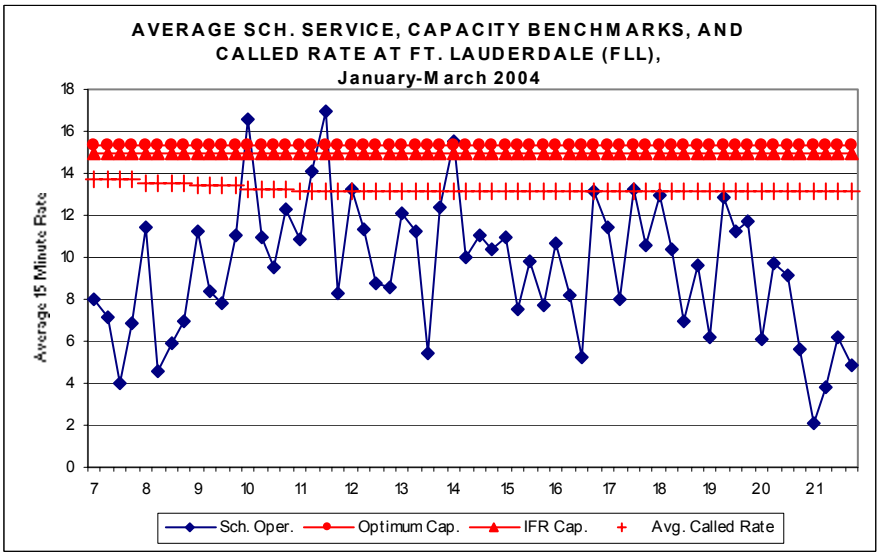




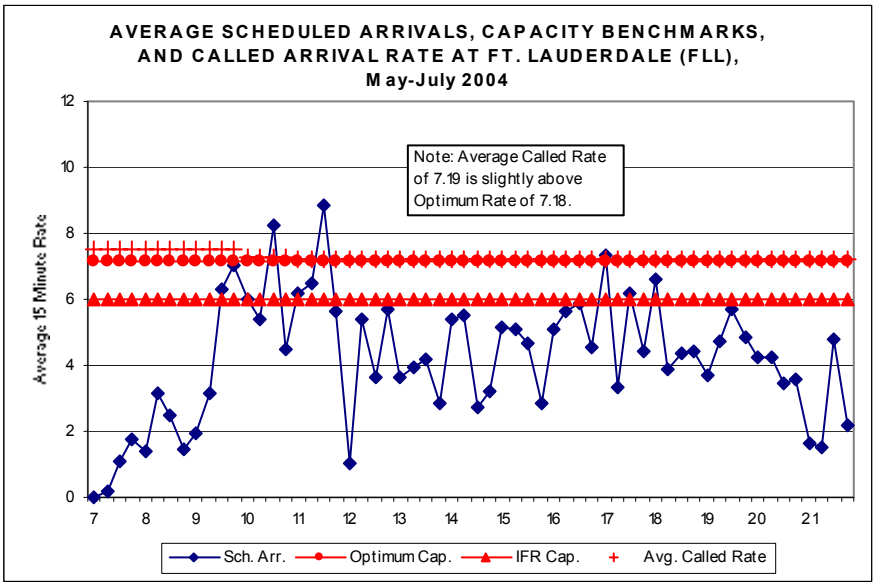
FLL – Ft. Lauderdale-Hollywood International
January-March 2004

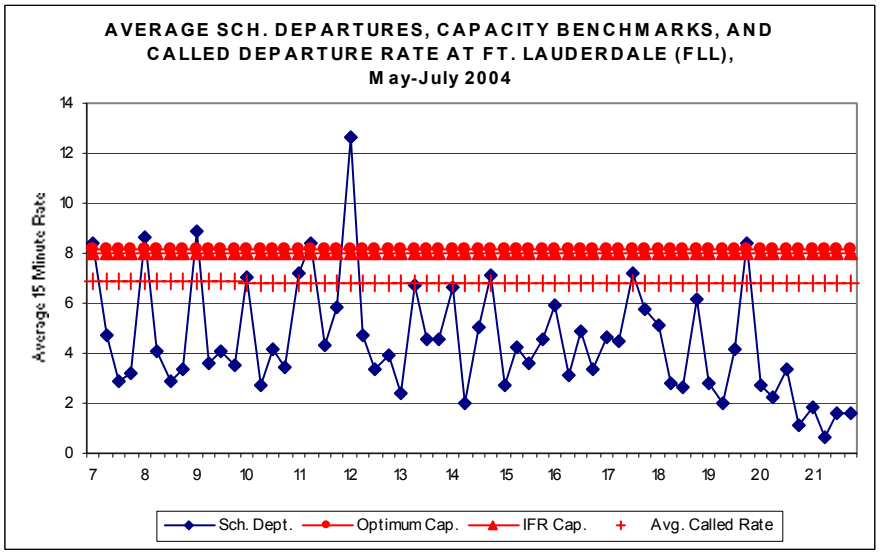


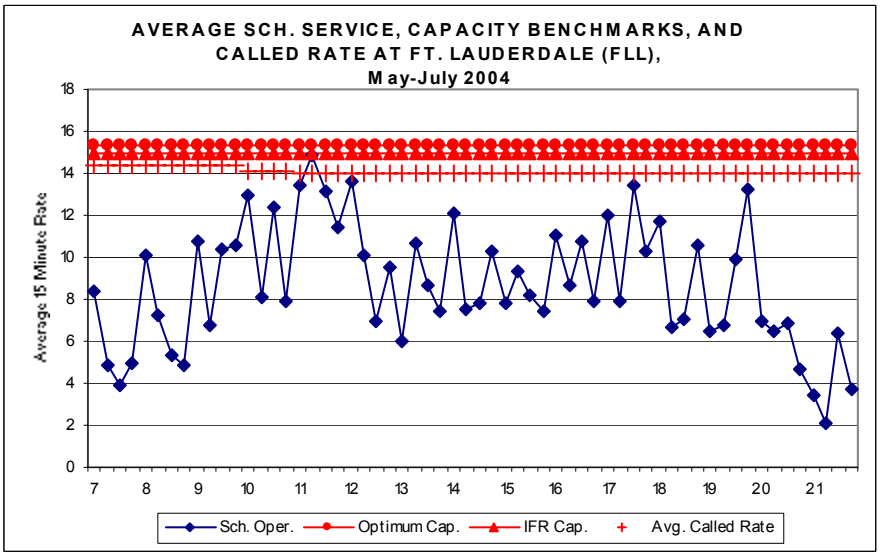




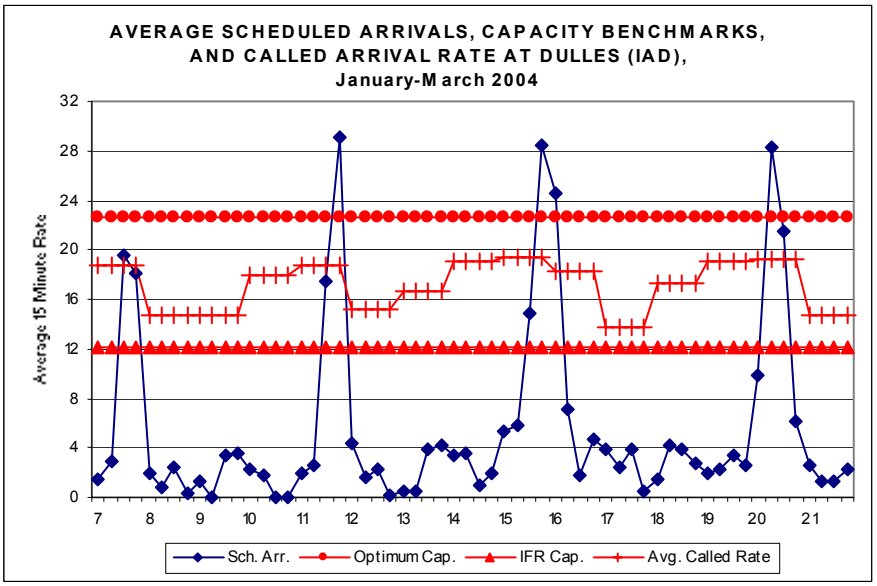
FLL – Ft. Lauderdale-Hollywood International
May-July 2004

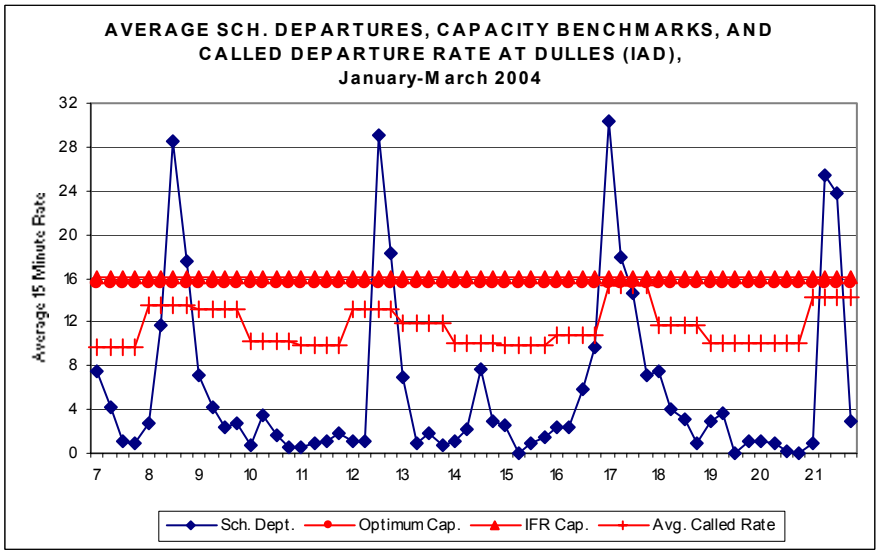


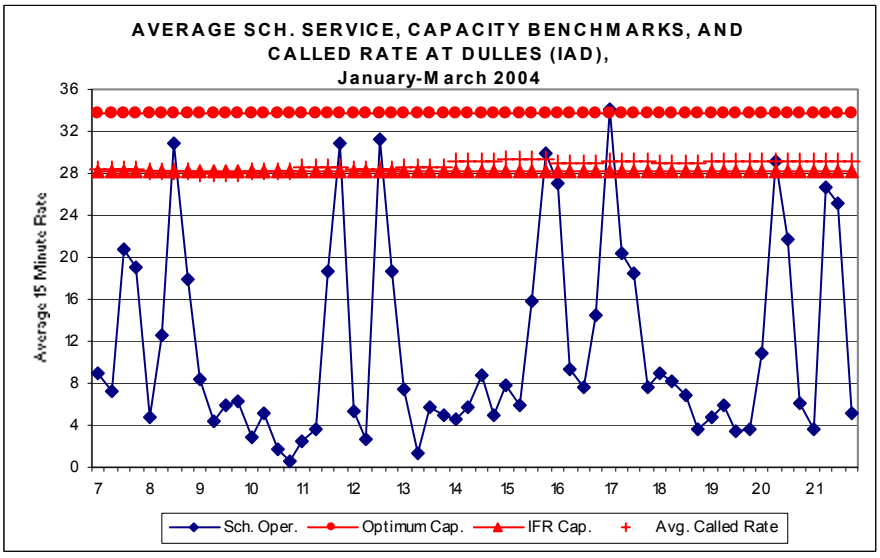




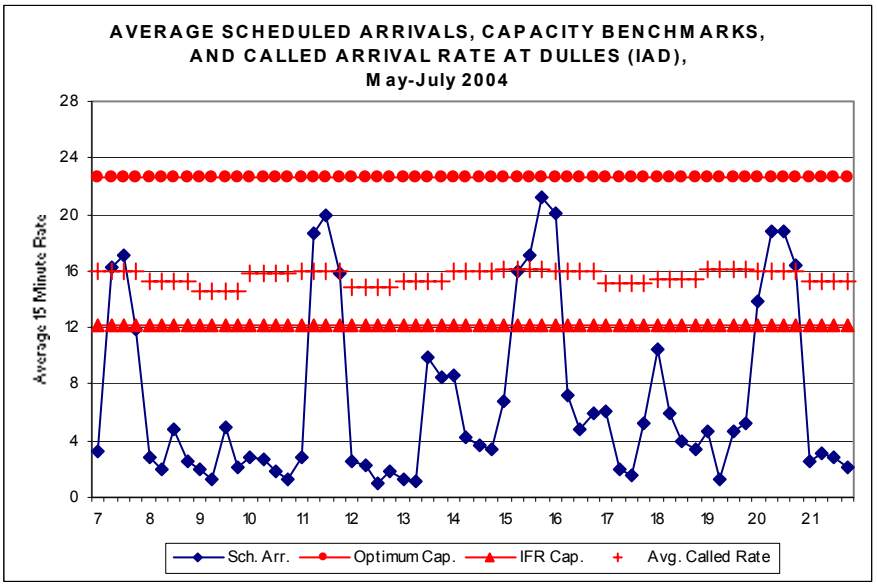
IAD – Washington Dulles International
January-March 2004

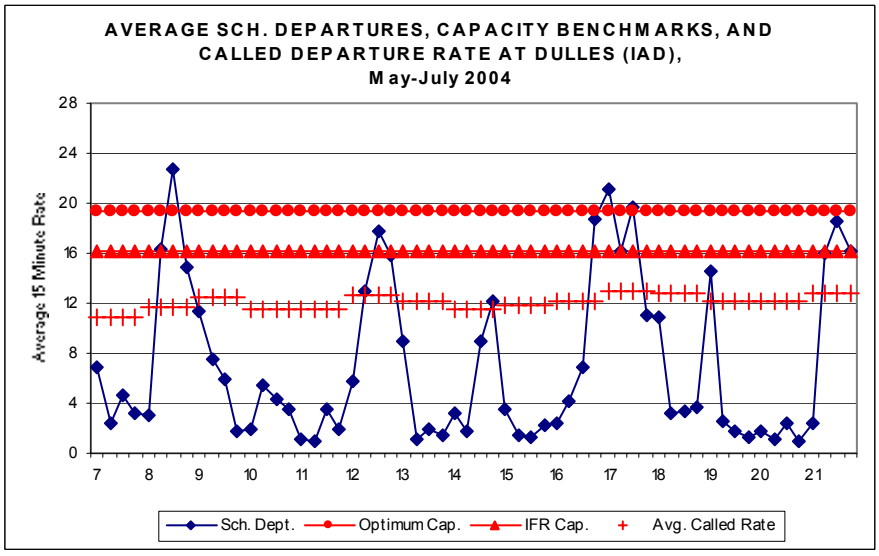


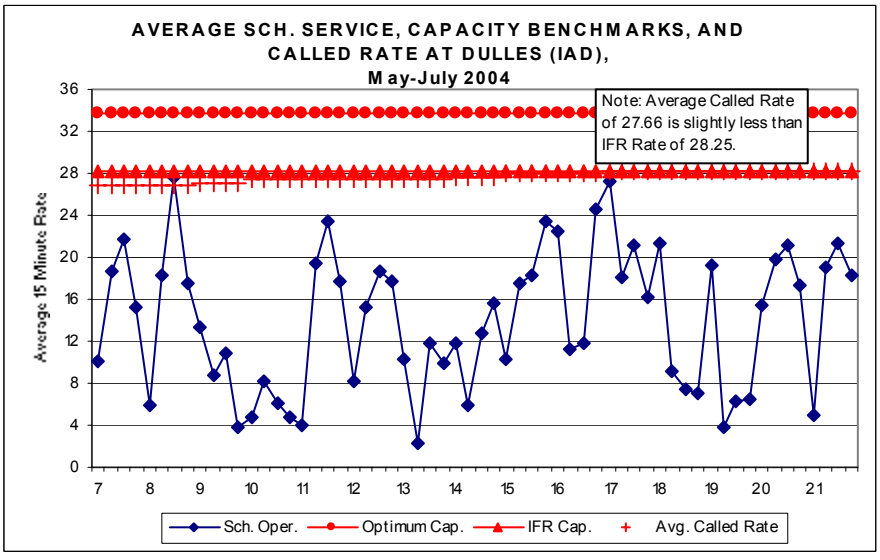




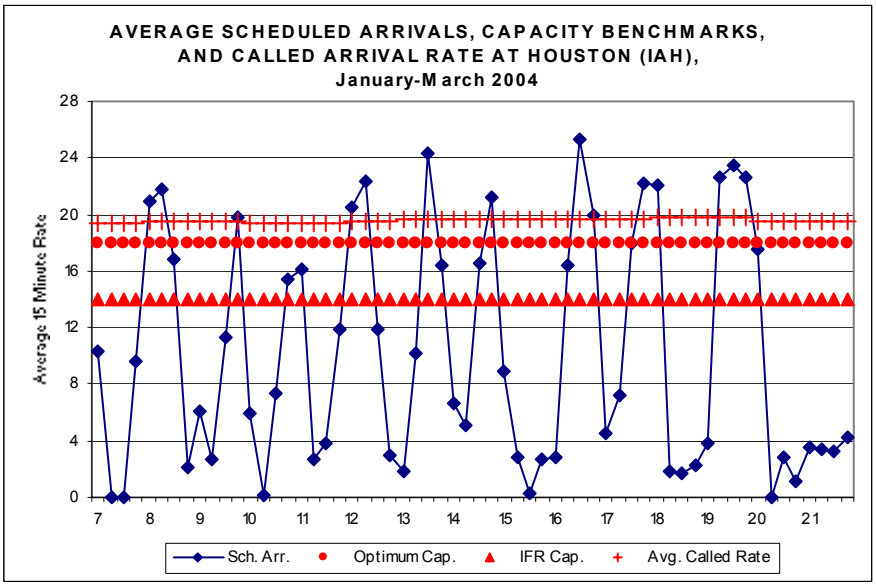
IAD – Washington Dulles International
May-July 2004

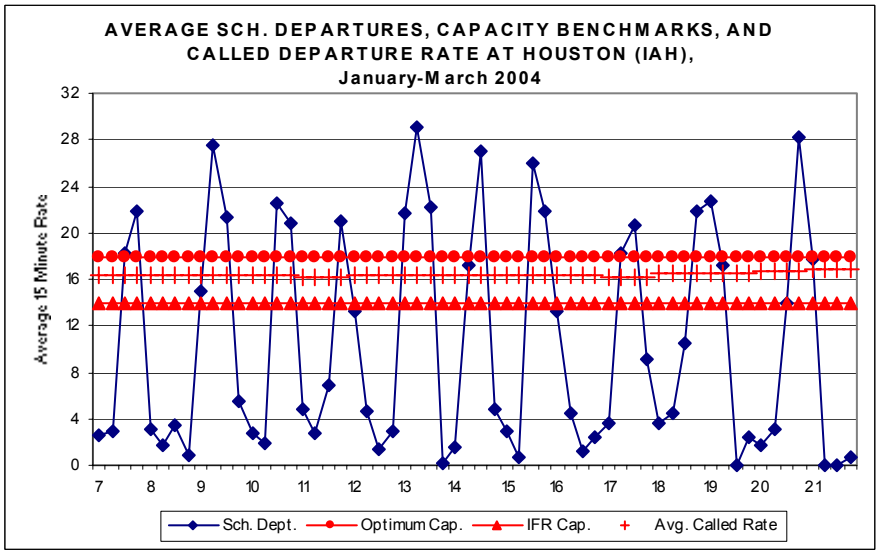


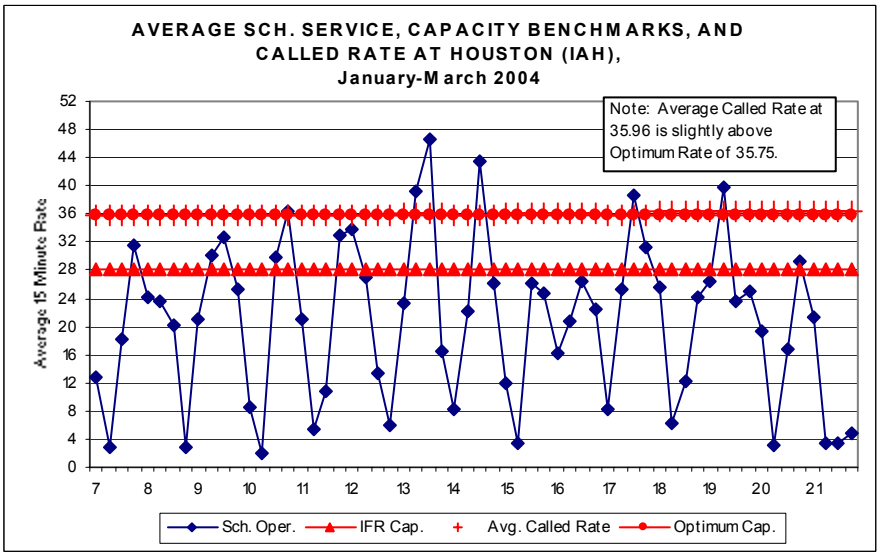




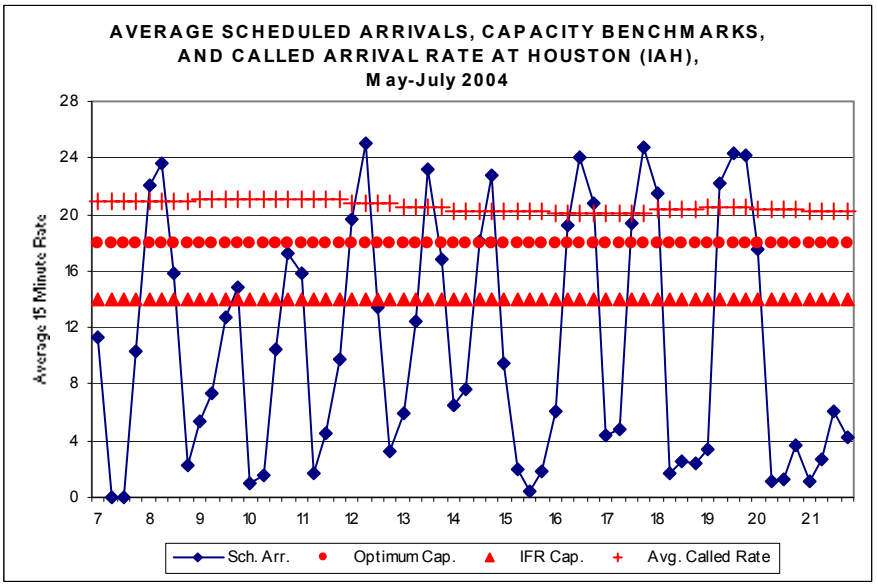
IAH – Houston George Bush Intercontinental
January-March 2004

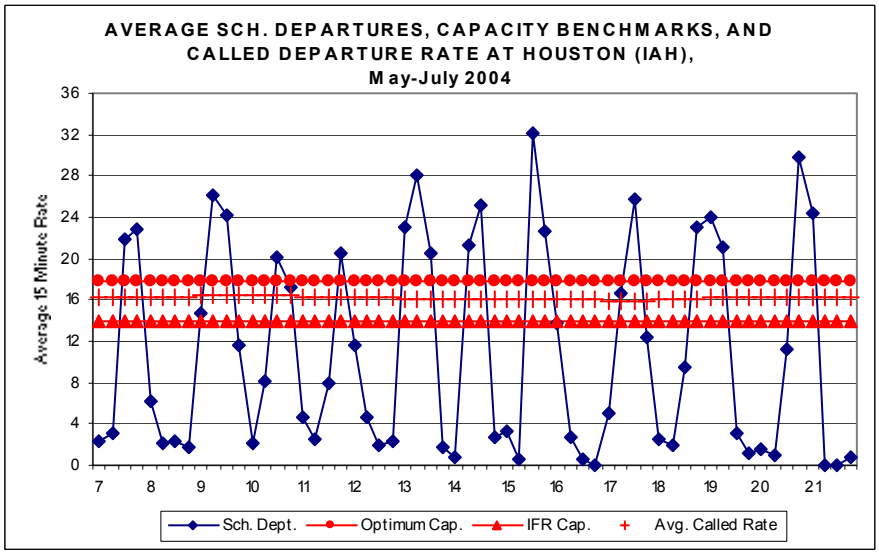


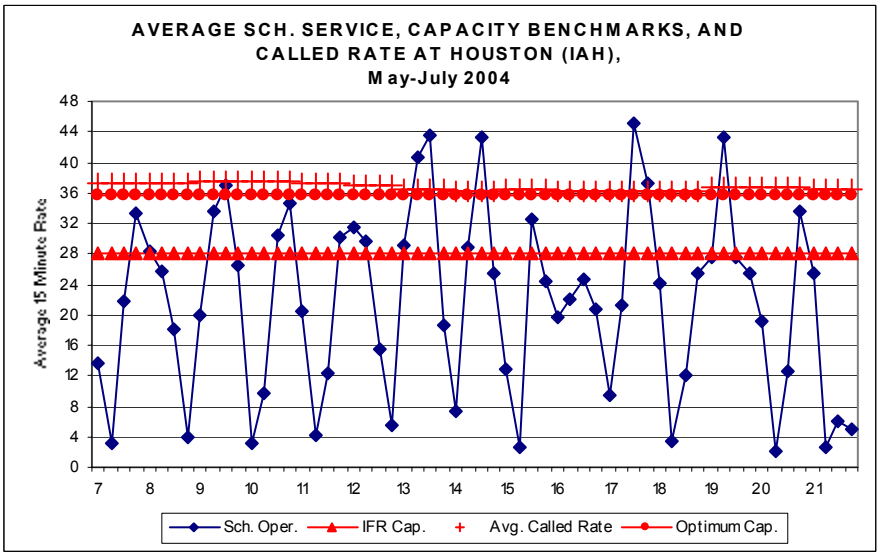




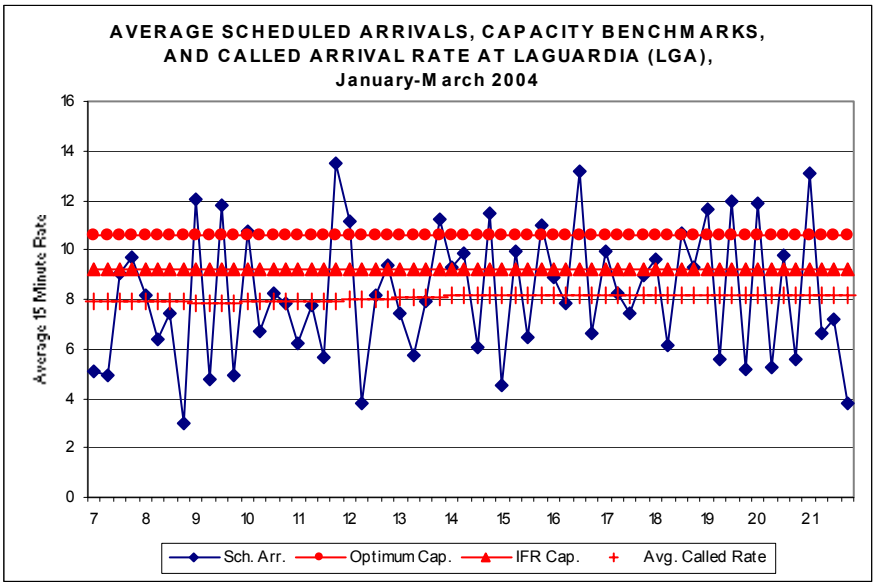
IAH – Houston George Bush Intercontinental
May-July 2004

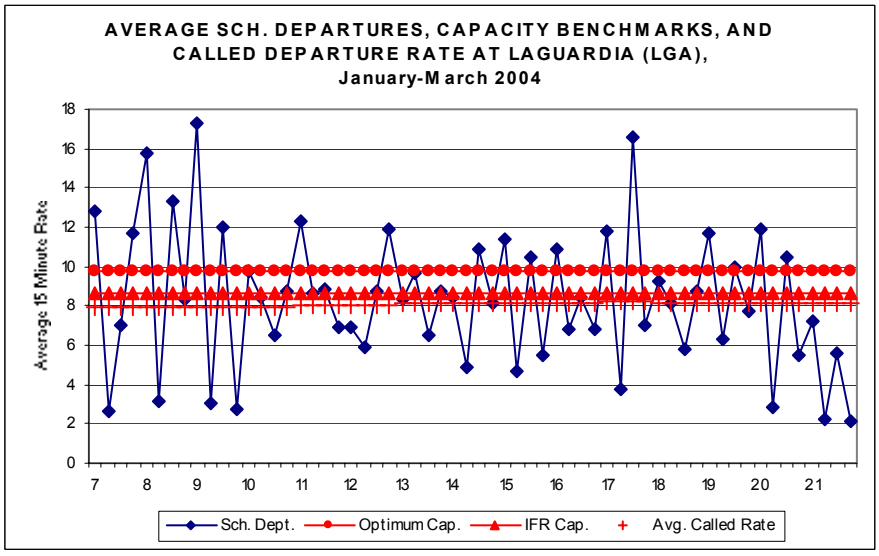


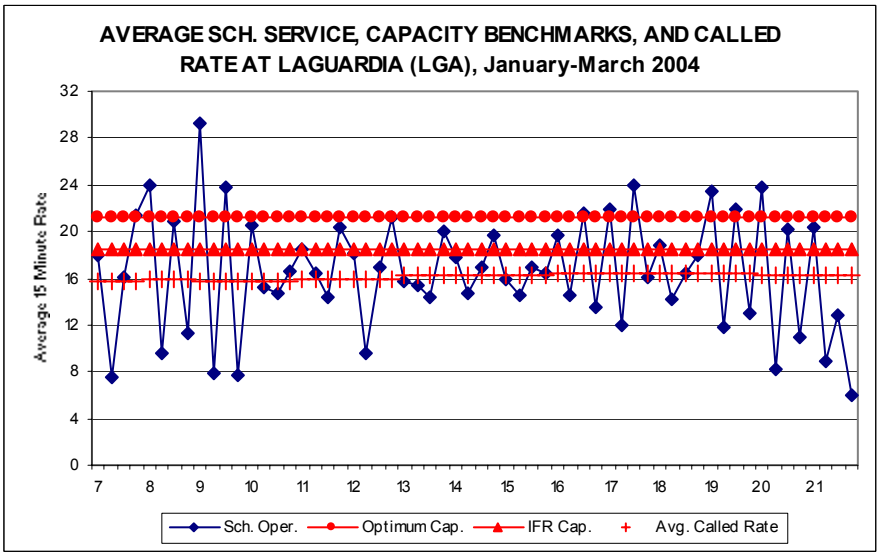




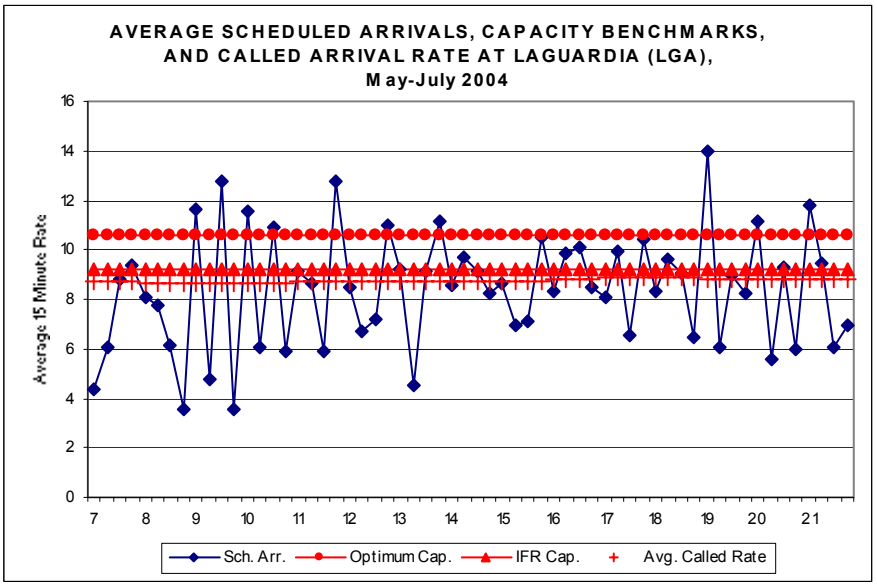
LGA – New York La Guardia
January-March 2004

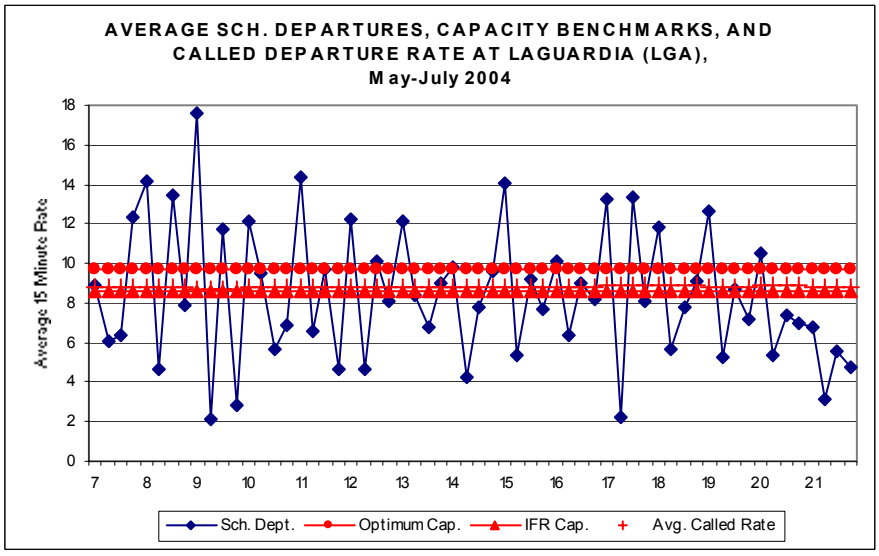


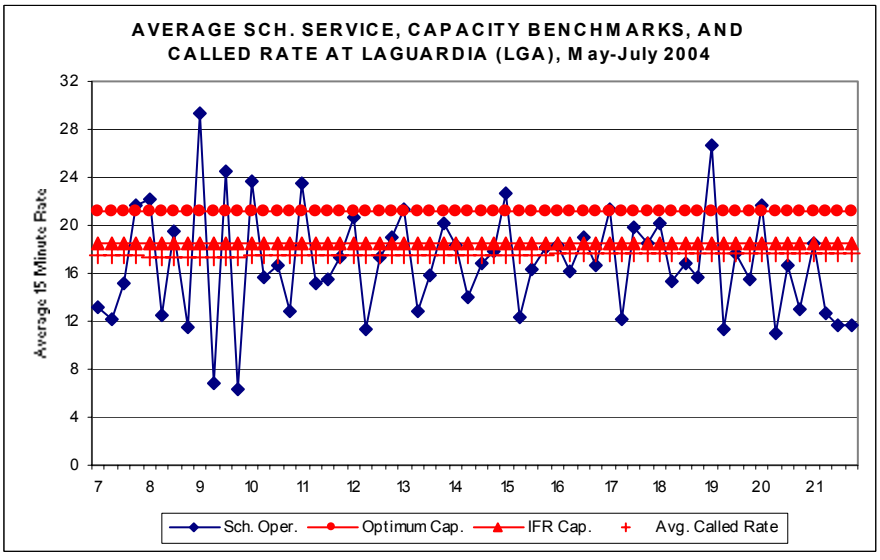




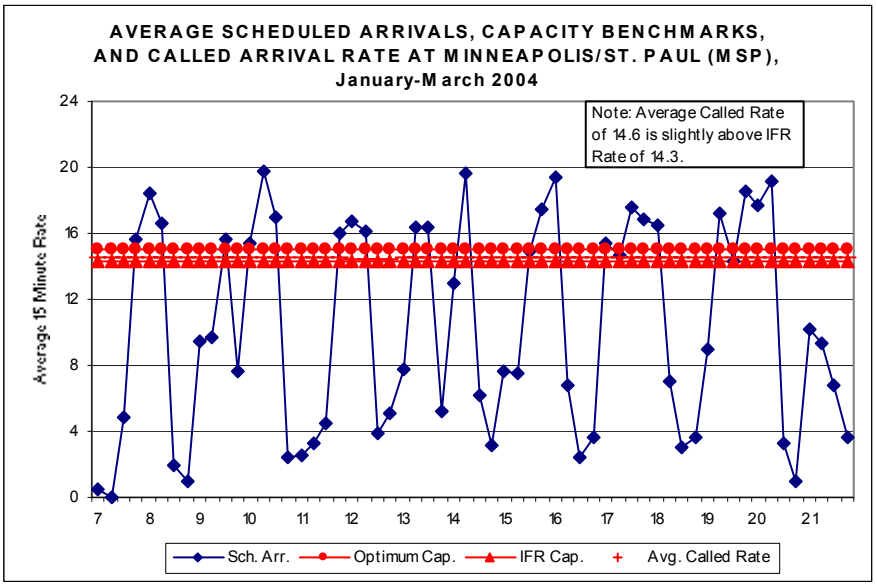
LGA – New York La Guardia
May-July 2004

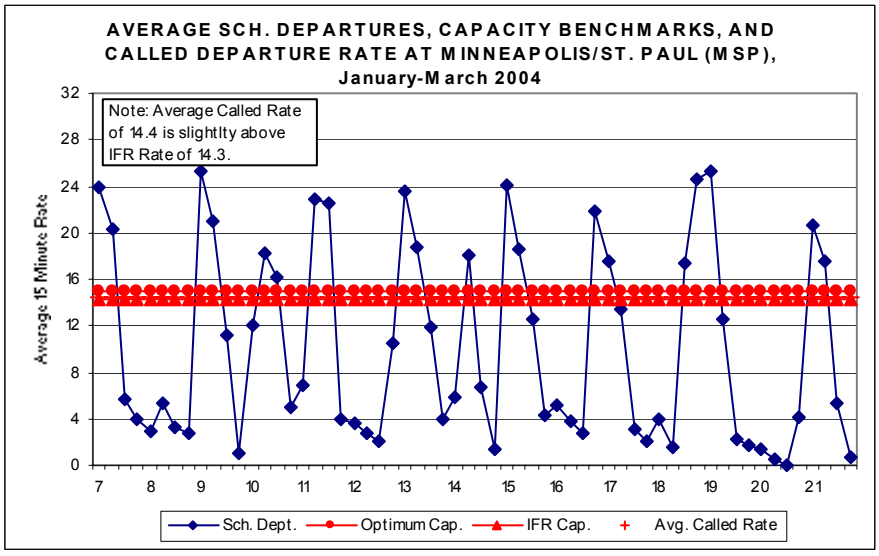


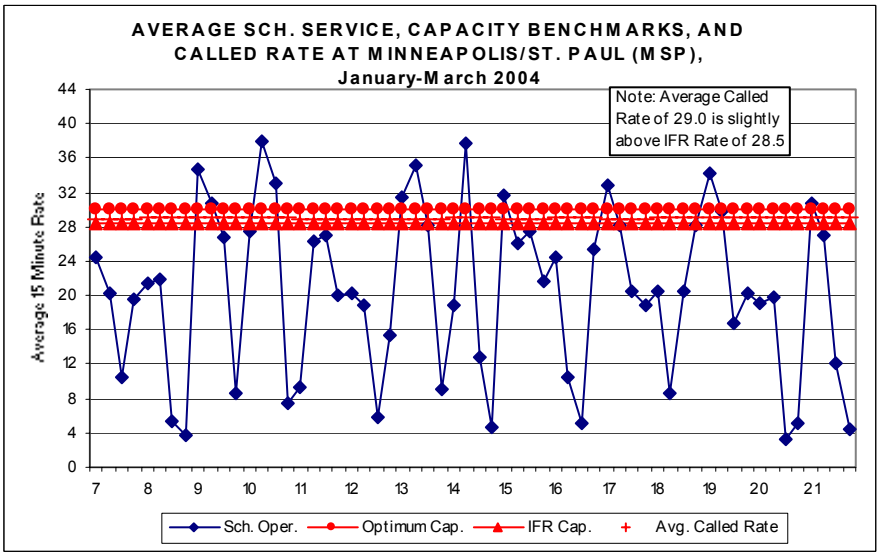




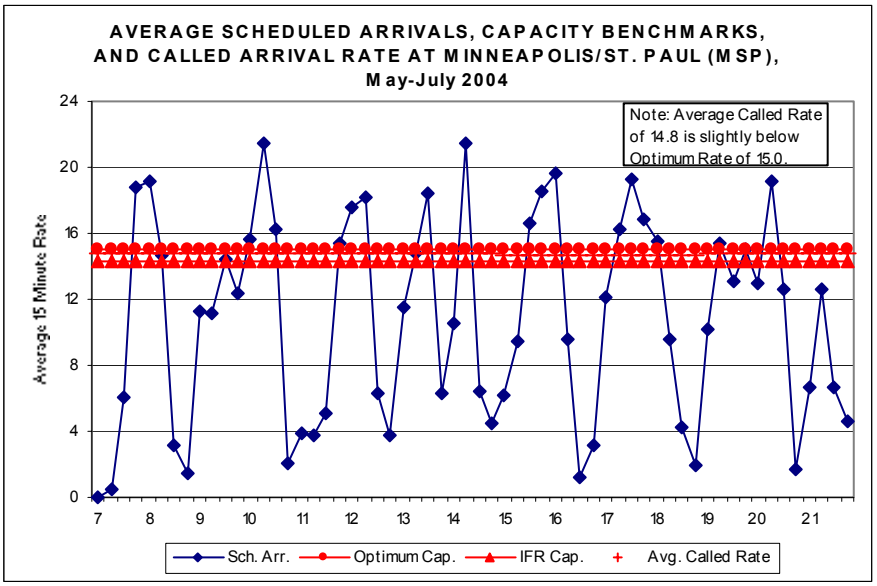
MSP – Minneapolis-St. Paul International
January-March 2004

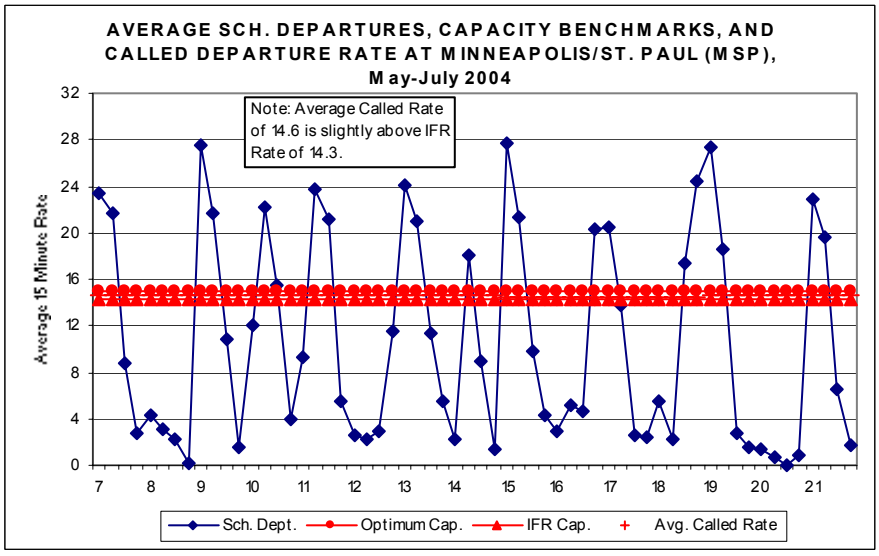


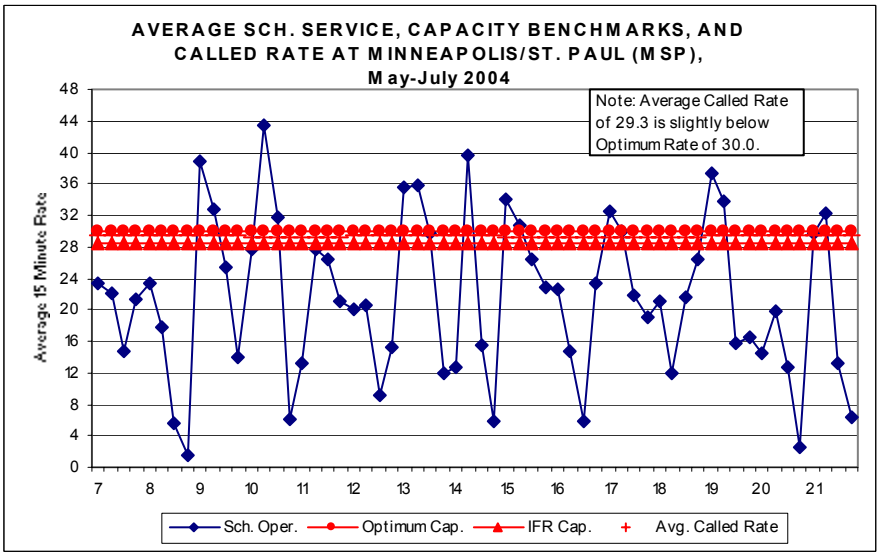




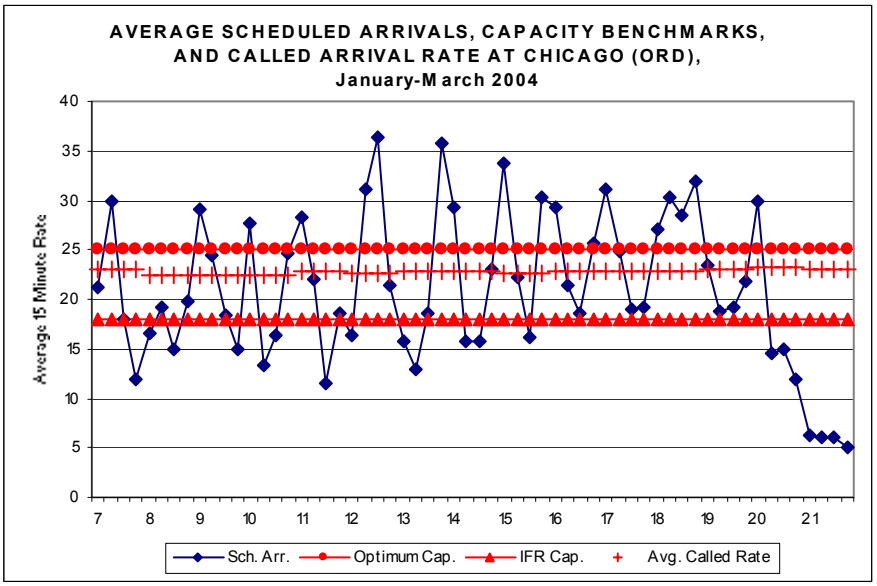
MSP – Minneapolis-St. Paul International
May-July 2004

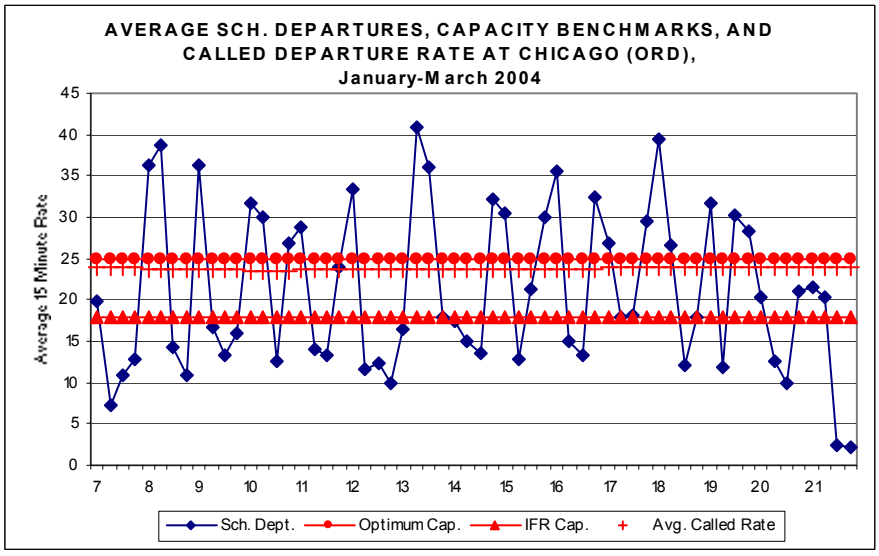


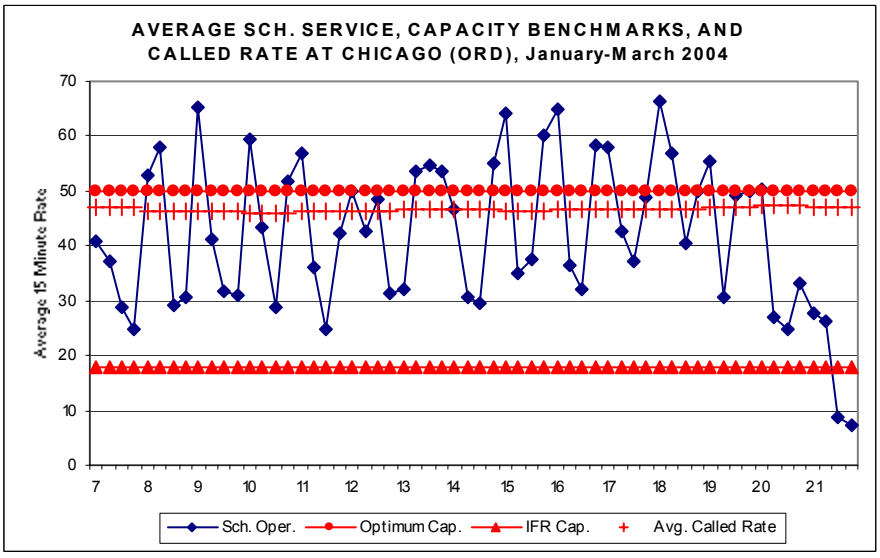




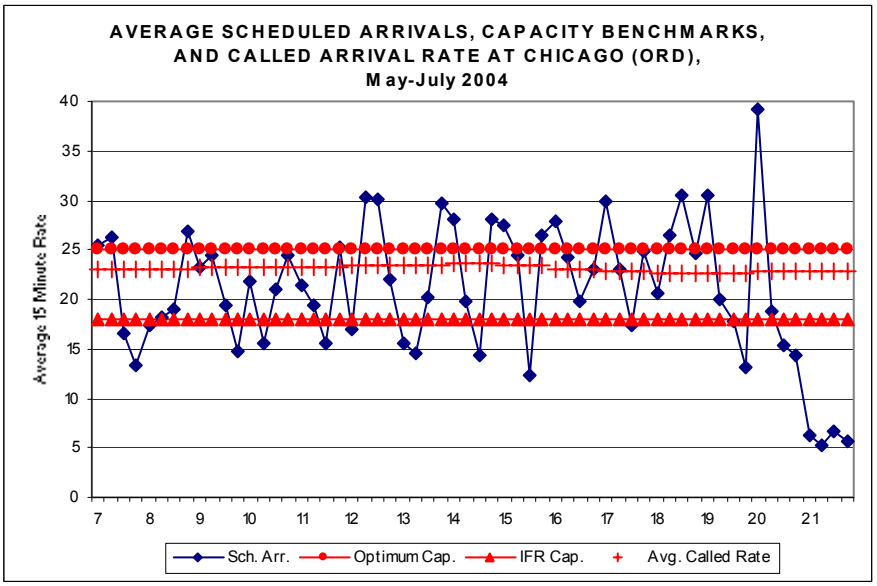
ORD – Chicago O'Hare International
January-March 2004

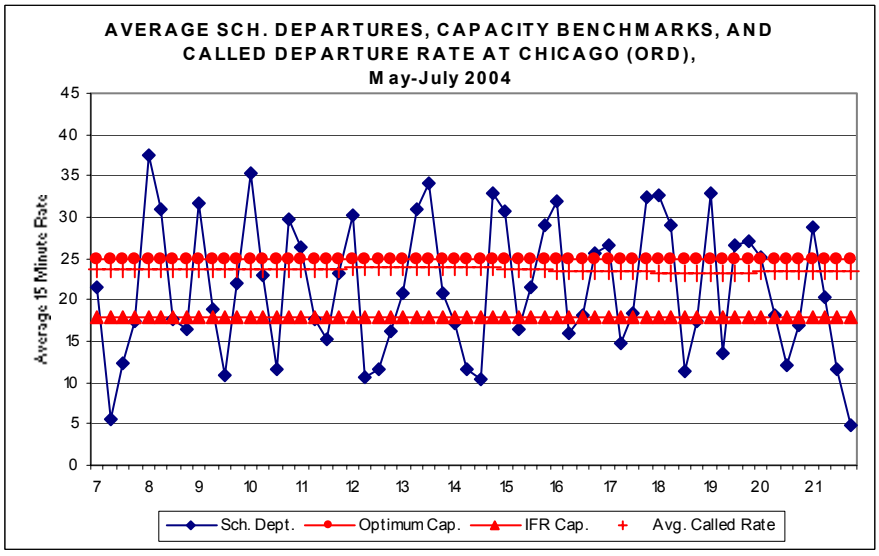


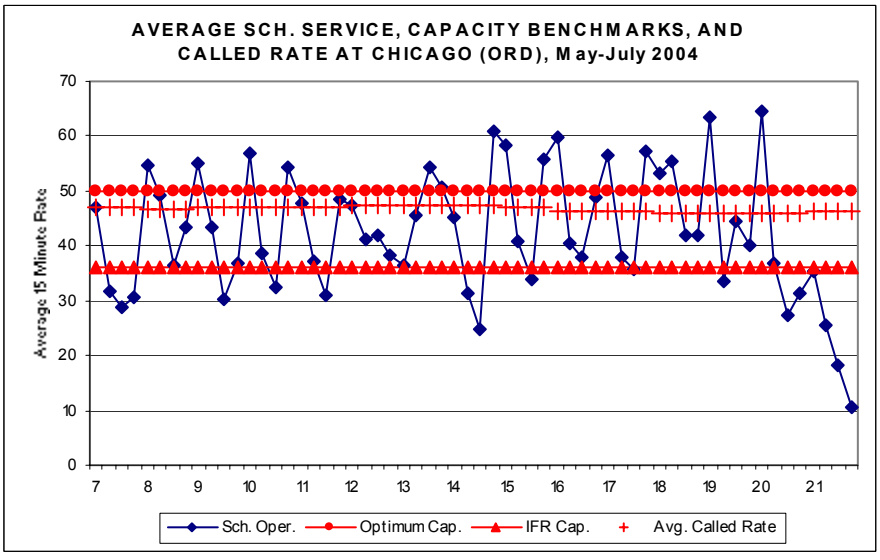




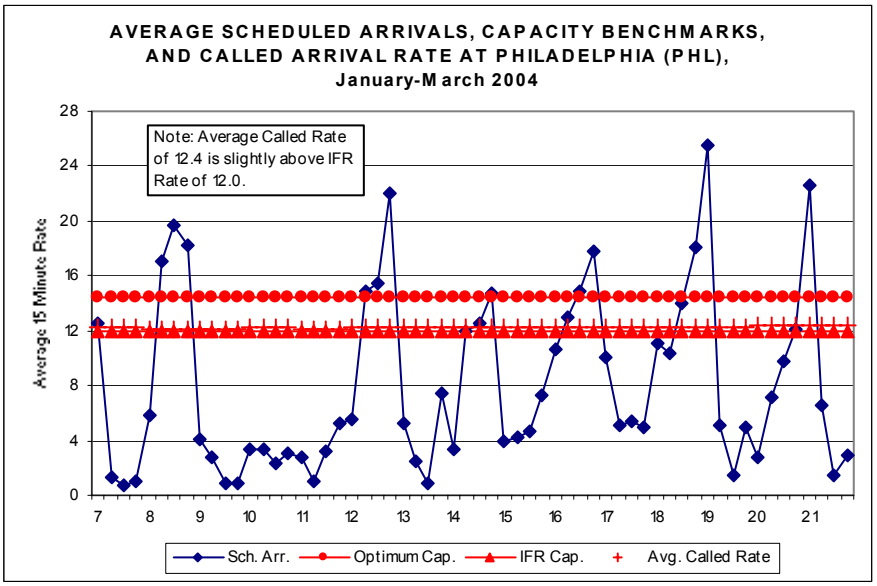
ORD – Chicago O'Hare International
May-July 2004

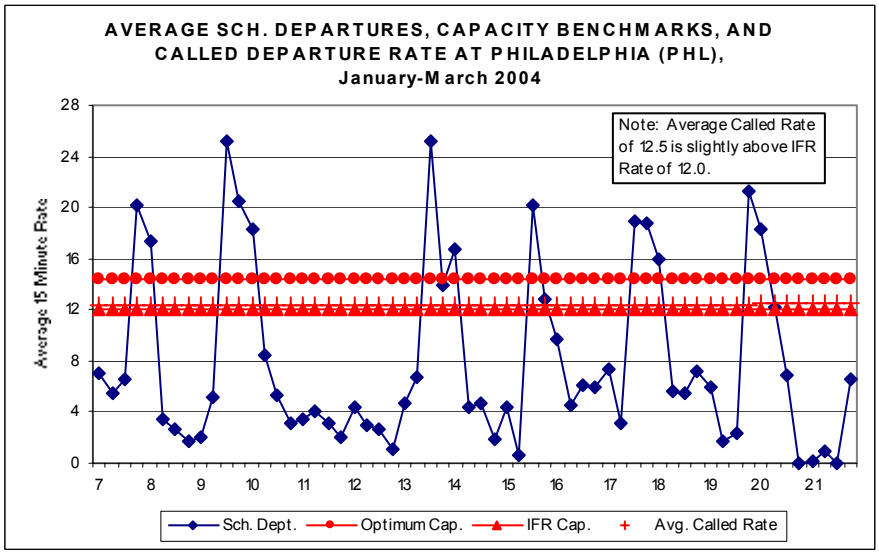


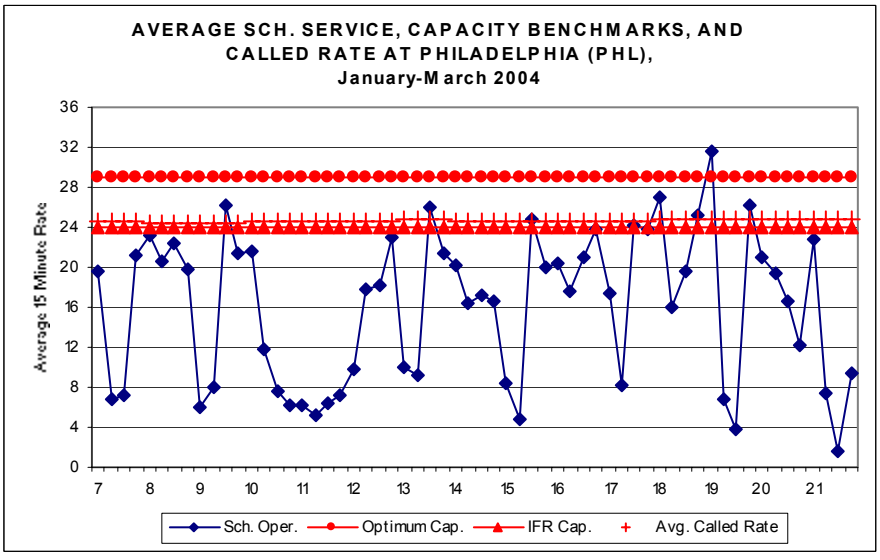
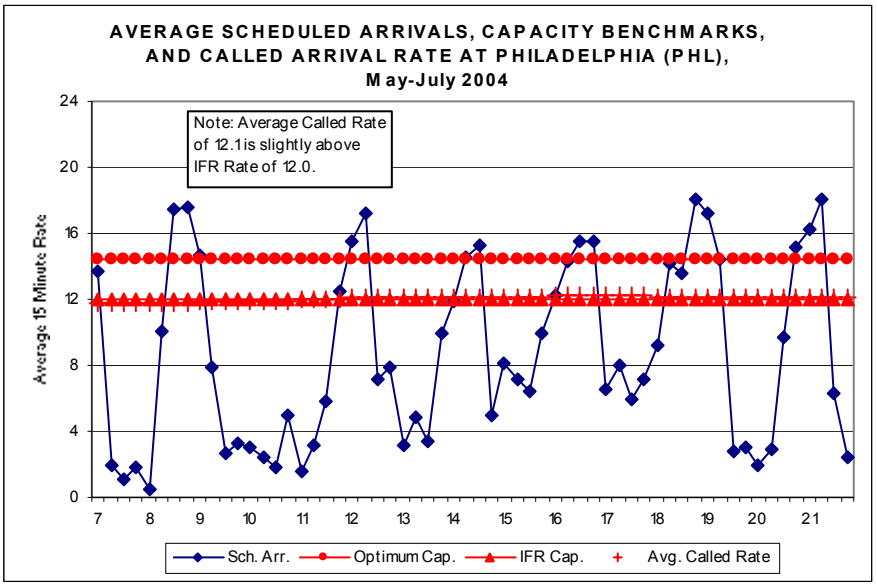
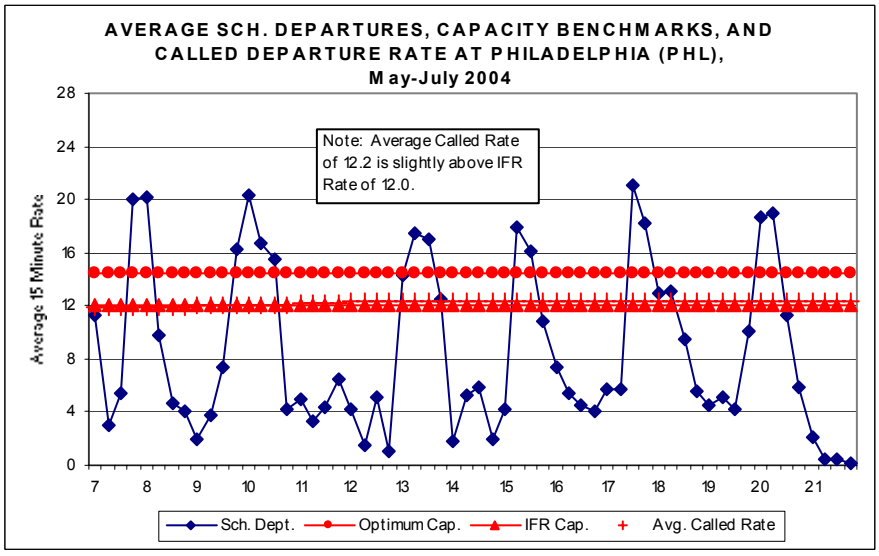
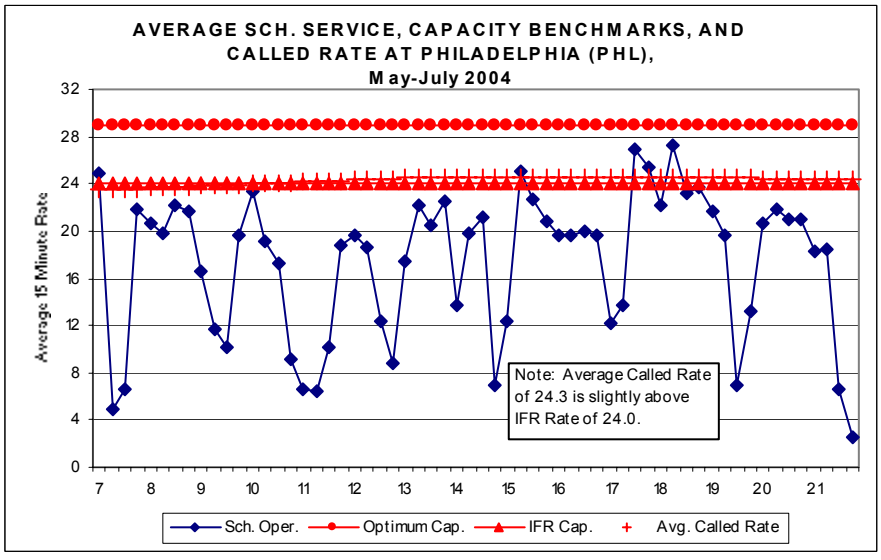




PHL – Philadelphia International
January-March 2004







PHL – Philadelphia International
May-July 2004